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The Resources of Small Engineering Firms

THE Engineering Industries Association has issued a memorandum this week directing attention to the concern which is being caused in the engineering industry by the shortage of liquid resources in small and medium-sized firms. The Association says that the gravity of the problem is revealed by the difficulty among small firms in financing the inflated price of raw materials and other costs. The introduction of additional private capital by directors or proprietors of small firms, the memorandum points out, is restricted by the penal level of taxation on private incomes, and, moreover, the incidence of death duties on private firms acts as a deterrent to the introduction of further capital into businesses. Many small engineering firms, the Association claims, are endeavouring to carry on with an overdraft limit which does not allow them adequate scope for their desired activities. To meet the difficulty, the Association suggests in its memorandum that Government departments, local authorities and nationalised industries should settle their accounts more promptly, and that the Inland Revenue department might adopt a more lenient course in collecting taxes. Other suggestions are that large main contractors, with adequate capital resources, might, in appropriate cases, grant more extended credit to sub-contractors, and that the Government should make available financial aid, both for capital and revenue requirements, in respect of Government contracts.

Coal Productivity Team for U.S.A.

THE latest specialist team to be organised by the Anglo-American Council on Productivity is one to study productivity in the coal industry in America. The sixteen members of this team have been nominated jointly by the National Coal Board and the trade unions concerned, and have been selected from all levels in the British coal-mining industry. The leader of the team is Mr. E. L. Chiverton, Production Director and Vice-Chairman of the South-Eastern Division of the National Coal Board. In view of the critical position of the coal industry in this country at present, the itinerary for the team has been planned specially to include a dozen American bituminous coalfields where conditions are said to be comparable with those prevailing here. One of the team's main aims, it is stated, will be to study methods of increasing production whilst economising in manpower. In addition to visits to mines, therefore, members of the team will inspect the products of American manufacturers of mining equipment, including coal-cleaning plant, and will also confer with the American Coal Association. But it is realised, of course, that mechanisation is only one aspect of the problem facing the coal industry in this country, and that human relations in the industry are also of great importance. In this connection, the productivity team will have facilities in America for studying methods of consultation and conciliation, welfare arrangements, and trade union procedure. The team expects to arrive in the U.S.A. on February 5th and will remain there until March 22nd.

The Ulster Transport Authority

THE annual report of the Ulster Transport Authority for the second year of its operations, ended September 30, 1950, was issued at the end of last week, and shows a trading loss for the year of £213,633, compared with a trading profit of £52,303 in the first year. The report says that the aggregate deficiency for the two years' operations is £544,216, the reason for the difference between the total deficiency and the trading loss of £161,330 for the two years being due mainly to the interest which the Authority is charged on its borrowings and its liability to redeem those borrowings. The deficiency on railway operations during the year reviewed was £323,098. Road passenger operations showed a profit of £259,272, compared with £359,231 for the first year, but road freight operations revealed a loss of £162,429 last year as against a loss of £93,128 in the preceding year. General comments made in the report on the Authority's results are that road passenger transport "may possibly lend itself to operation at a reasonable profit, though the volume of traffic may not be maintained," and that road freight transport will probably be run at a loss as the volume of traffic handled by it is likely to decrease from year to year as more private lorries are put on the road. About the railways, the report comments that there is not the business available which will enable them to earn a net revenue, and losses, at least in the immediate future, are likely to be substantial.

Private Generating Plant

THE British Electricity Authority and the fourteen Area Electricity Boards have decided to extend until March 31, 1956, the relaxations of restrictions made in 1948 to enable industrialists to install private generating plant, should they so desire. After the 1947 fuel crisis the Government encouraged the installation of private generating plant, mainly oil-driven, by commercial and industrial establishments. The plants, which were relatively small, were not intended to deal with the whole of the power requirements of the establishments they served, but to supplement supplies taken from the electricity supply industry. To provide an electricity supply that is only partly or occasionally used is relatively uneconomic from the standpoint of the supplier. In pursuance of Government policy, however, the electricity supply industry agreed to the waiving of conditions under electricity supply contracts which prevented the installation or use of private generating plant, and granted concessions in charges for standby supplies required in association with the use of such plant. In 1948 the British Electricity Authority and the Area Electricity Boards reviewed the position and consulted the Federation of British Industries. The Authority and the Boards decided to continue the relaxations and concessions up to March 31, 1952, by which time, it was hoped, the power plant shortage would have been substantially overcome. In view of the continuing shortages, it has now been decided further to continue these arrangements until March 31, 1956.

The Demand for Metallurgists

THE Ministry of Labour has now published the twelfth, and last, of the series of reports, prepared for its Technical and Scientific Register, on the present and future demand for and supply of workers with professional qualifications in science, engineering, architecture and surveying. This report deals with metallurgists. It was produced by a sub-committee of Lord Hankey's technical personnel committee, under the chairmanship of Sir William Griffiths. The report says that the estimate of the possible demand has perhaps been one of greater difficulty than that experienced by some other sub-committees, since, for the most part, metallurgists are employed in small numbers by a wide range of firms in many different industries. The sub-committee has reached the conclusion, however, that something approaching 1000 metallurgists, qualified with at least a pass degree, will be available from the universities during the period 1950–1954, and it estimates the total "supply" between 1950 and 1954 at around 1150. Taking all considerations of the demand position into account, the report puts the number of metallurgists likely to be required in the period 1950 to 1954 at 1350. The report says that, although the overall shortage may not be great, the supply of suitably trained metallurgists for research and teaching may well be more than sufficient, while there is likely to be a definite shortage of those suitable for works production and related activities. In this connection the sub-committee notes with some anxiety the reports of some firms and professors that many graduates are disinclined to take up industrial posts involving night and week-end duties, or other working conditions recognised as essential in industry. Among its general conclusions, the sub-committee thinks that "active and urgent consideration" should be given by those concerned to the question of whether the training of metallurgists intending to enter industry is best suited to the needs of the times. It also suggests that efforts should be continued to interest school teachers and scholars in the possibilities of a career in metallurgy.

The National Packaging Exhibition

THE second National Packaging Exhibition was opened at Olympia, London, on Tuesday last, January 30th, and will remain open until Friday, February 9th. This exhibition covers the packaging requirements of practically every branch of industry, and in it are shown many representative types of equipment for filling, labelling, closing, bottling, &c., as used in this country, America and on the Continent. From the engineering angle particular interest attaches to a complete mobile metal drum-making factory which has been designed to meet the needs of oil and similar companies working in undeveloped areas. The use of such a factory makes it possible to avoid the expense of building a pipe-line, operating a fleet of tankers, or transporting empty drums to the site to bring the oil back to civilisation. The mobile factory is built complete with plant and equipment for producing painted and printed drums from flat sheet on site, and includes accommodation and amenities for the operating staff. With its specially trained staff the factory can be laid down in a very short time, and in tests it is stated to have produced the first drum within eighty minutes of reaching its site. The Institute of Packaging has been very closely concerned with the exhibition, and whilst it is open a number of lectures on packaging subjects are being given. Among these talks will be one given by a railway executive on the subject of packaging for rail transport; in another a department store executive will deal with packaging for the special needs of large stores. Packaging for dollar markets will be described by the director-general of the British Export Trade Research Organisation, and the specialist team organised by the Anglo-American Council on Productivity will be available to answer questions on American practice.

Productivity in British Industry*

No. XVII—PRODUCTIVITY, AUTHORITY AND RESPONSIBILITY

By W. B. D. BROWN†

PRODUCTIVITY, Authority and Responsibility are not, I think, felt by the average person in industry to be as closely associated as, in fact, I believe to be the case. I have chosen this title in an endeavour to demonstrate that we shall not deal effectively with the problem of productivity until we realise the parallel necessity of looking simultaneously at the problems of authority and responsibility as well. I have come to feel that very few single problems can be isolated from other problems in industry. I must make this clearer. If we succeed somehow in raising productivity, we shall also raise morale, move further away from wage disputes, and lessen feelings of insecurity, especially amongst managers. Again, if we begin to lessen suspicions between workers themselves, between workers and supervision, between technicians and supervision, between middle management and top management, &c., then is it not true that we shall also have started along the road to solve the problem of productivity ?

Many problems appear to be associated solely with change of machinery or materials or process, and it is therefore often assumed that such changes can be implemented without effect on people. In fact, however, any change to anything in industry does affect people, because everything that happens in industry starts and finishes with people. All things in industry are either initiated, accepted, resisted or implemented by people. Therefore, the problem of productivity is not only a materialistic technical problem; it is also a human problem.

There is nothing new in what has been said so far. Nevertheless, I think these rather obvious concepts are often brushed aside. As a result, we do not get the results from proposed change which we hope for.

Disappointing Results from New Methods

Technicians work out new tooling and methods which, theoretically, should yield x per cent more output, but much less than that is achieved. The reasons for this may be many and varied. Perhaps the shop managers express doubts about the validity of the technical change, but they are overridden on the grounds that "there isn't time to convince everybody." Then bargaining with the shop stewards takes place about the new output times which are necessary ; some of the comments made are unreasonable and anger managers because they are not recognised as being an expression of deep anxieties about the total intentions of management, and are taken at their face value. Perhaps owing to the urgency of the commercial situation, pressure is applied, and instead of an agreed basis of introduction of the new methods, some rather uneasy compromise results. And so the technical change is introduced in a situation where the managers, supervisors and workers all feel uneasy and suspicious. Such a situation produces disappointing results. Senior managers feel that foremen are not really trying to make new ideas work, and that workers are not playing the game. They may by their attitude indicate that they have such feelings. Floor management pick out one or two minor inadequacies of the new methods to justify their initial opposition, and feel, "Why don't these production people and draughtsmen use some of our experience instead of trying to hand it all on a plate to us as though we knew nothing ? " This sort of morass of feeling is not, I think, uncommon, but there is not sufficient recognition of the extent to which this kind of attitude of mind is getting in the way of increased productivity.

All this feeling is about types of change which have to happen repeatedly, and it results in a situation where nobody feels encouraged to propose or accept more changes of process and method than are absolutely forced upon them. There is some danger that senior managers will abdicate their responsibility for proposing change, because they do not feel capable of handling the emotional situation which always seems to arise.

My example refers to change on the production floor, but whatever the position we occupy in industry I think we are equally affected. It seems to matter little whether the change be small or large-scale, whether it applies to new products or machines, or whether it is a plan for rearranging the work of clerks, technicians or salesmen. We get the same type of feeling amongst our directors and senior managers of industry if the Government imposes change upon the affairs of industry. In these situations, I, for instance, find my own feelings to be very similar to those apparently felt by workers and shop stewards in the face of change proposed to them. I am impressed, for instance, by the pretty consistent opposition to the whole conception of Government planning which so often comes from the ranks of managers. Now, we managers are professional planners. It would not, I think, be an illogical assumption to expect us, who spend our lives planning the economic life of others, to be the first to accept the necessity for national economic planning. But whilst we continue to operate what are possibly the most highly planned units of modern society, i.e., our factories, wherein people find themselves most closely ringed around with rules and regulations, we managers often display what seems to be disproportionate anxiety about the much less intensive forms of planning worked out by the Government.

Sociological Problems

My thesis, then, is that we cannot solve the problems presented by our urgent need for higher productivity in the back room alone. We require to approach this problem on a broader front. It is not a question of dropping off technical effort and concentrating on joint consultation, or some other technique, nor can we solve these problems at the superficial level of a new incentive scheme or a training course to show foremen how to "lead" workers. The situation requires that we face the fact that we are living in times of great social change, and that we have not only technical and administrative problems, but that we also have sociological problems too which must be recognised and faced.

Now, these latter problems are more difficult to face than the technical problems, because we have no conventional method of dealing with them and because, I think, we recognise, perhaps subconsciously, that if we are realistic we may have to accept the fact that the solutions lie in change in our own behaviour, and that is a disturbing thought. We may have to work out and accept a new status and a new role for ourselves, as a prelude to helping others along the same lines. Are we not, in fact, in the face of the current industrial problem, ready for almost anything except change that affects us personally, and, in fact, is that not the very point at which we may have to start, if we are to solve the sort of problems that I have referred to ?

Recognising, then, that nothing that we can do is a substitute for sound technical research and development, but that other realms of research and thinking exist, which must be simultaneously explored if we are to solve our problems, and particularly our problem of productivity, I want to turn to this sociological field for the rest of this article. This is the field where the least research has been done. This is the field in which we are least inclined to go digging, because we may unearth problems which we really want to leave buried. This is the field which, if explored, may yield up findings which mean change that impinges upon us as managers personally, instead of on others.

What follows is my attempt to think objectively about some of the problems that beset us in this field. I am not claiming that my views are the result of scientific research; I claim no validity for them, but I do claim that these sorts of untried hypotheses require testing out scientifically.

Autocracy

Industry normally operates within a framework of autocratic culture. This is not to say that all factories are in fact run autocratically ; it does mean that people feel that at any moment they may find themselves subject to the arbitrary will of others higher up, without the right of appeal to an independent system of justice. This situation seems to spring from one of the accidents of history, whereby one particular party to the total industrial process, the shareholders, possess the right at law through appointed directors to make nearly all decisions without the consent of the other parties, if they so desire. It seems that the feeling is growing that this position is unsound, for there are at least three other clear interests—those of the manager, the worker and the consumer—who at law can be ignored by ownership interests. There seems to be some evidence that the lack of satisfaction derived by managers and workers from their daily labours is at least related to this situation, and to the autocratic culture which stems from the situation.

This situation has been tolerated in the past because unemployment gave great power to directors, and, in turn, managers, who either chose to or had to impose

* No. I, "An Introductory Survey," by B. White, appeared February 17th ; No. II, "The Threshold of Productivity," by F. A. Martin, March 3rd ; No. III, "High Productivity and Production Costs," by Sir Claude Gibb and Gordon M. Baker, March 17th ; No. IV, "Standardisation in the Aircraft Industry," by E. C. Bowyer, March 31st ; No. V, "Restrictive Practices," by Arthur Woodburn, April 21st ; No. VI, "Research for Productivity," by Dr. D. F. Galloway, May 19th ; No. VII, "Consequences of Simplification," by W. D. King and H. Sherburn, June 30th ; No. VIII, "Works Extensions," by C. K. F. Hague, July 28th and August 4th ; No. IX, "Mechanical Handling," by F. Garner and A. Siddall, August 11th and 18th ; No. X, "The Importance of the Craftsman," by F. V. Everard, September 1st ; No. XI, "Productivity in the Smaller Engineering Works," by Antony Vickers, September 15th ; No. XII, "Productivity in Civil Engineering," by Lieut.-Colonel C. M. Norrie, September 29th ; No. XIII, "The Measurement of Productivity," by L. H. C. Tippett, October 13th ; No. XIV, "The Contribution of the Machine Tool Industry," by J. B. S. Gabriel, October 20th ; No. XV, "Safety in Industry," by Sir Alfred Herbert, October 27th and November 3rd ; No, XVI, "Factors Affecting Production," by E. W. Steele and W. Symes, December 22nd.

† Director, Glacier Metal Company, Ltd.

arbitrary decisions. Workers, in turn, were prepared to submit to the situation rather than risk losing jobs.

Full employment has changed the situation, and in industry to-day the power position between shareholder, manager and worker is more evenly divided. People do not fear so vividly the loss of a particular job because the prospects of getting alternative jobs are so much better. Managers are much more concerned to retain people in their jobs than previously, because of the difficulty of replacement and a wider appreciation of the heavy costs in terms of output and morale of a high labour turnover. Because of changes of this sort the situation is felt by many to be different. Because people all feel a sense of difference the "boss-worker" relationship is breaking down. People do not want a situation in which management ceases to manage, but, on the other hand, they equally do not want a continuation of the pre-war situation where management had too much power to push other people around. Confusion over these sort of feelings is holding up the taking of responsibility, particularly by workers, for increased productivity.

If, in fact, managers have lost complete power over the situation, then it is true that they cannot also be called upon to carry complete responsibility for the situation. This can be put in another way. If power in industry has been redistributed, then the responsibility that is always associated with power has also been redistributed. Because full employment and many other factors have given unions and workers more power, then means must be worked out to give them some of the responsibility that is associated with that power. It is necessary, therefore, to develop the new situation in industry so that both managers and workers find themselves able to shoulder and carry out their respective responsibilities, and to face jointly the problem of how to increase productivity.

Can we work out tentative ideas on how this can be achieved ?

Function and Status of Management

It is surely essential that the function and status of management is understood and agreed by all, because unless everybody agrees just what the job of a manager is, and he has the backing of all sections of industry in doing it, then either he will try in desperation to resort to the use of arbitrary power, which he has no longer got, or he will have to throw in his hand. There is a good deal of evidence to suggest that this is the position to-day. In many industries things happen daily of which nobody approves, management have insufficient authority to stop malpractice, workers do not feel it is their responsibility to do so, all dislike the position. For instance, the prevalent habit in some industries of stopping work long before recognised finishing times, the existence of out-dated schemes of piecework pricing, as in the cotton industry until recently, and the retention of methods which are known to be out of date and which could be improved, are examples which will be familiar to most people.

Can we look at management in a different way ?

Policy Decisions

The job of management (not of managers) is the whole task of deciding policy and putting that policy into action. In the past, directors and managers have done all this unaided. The first part of management, that of deciding policy, could be carried out by directors, managers and workers as equal partners in the process. Managers would have to take into account the interests of consumers, directors, other managers, technicians, &c., and the workers the interests of those they represent and of trade unions as a whole. Because in the new situation no one can be coerced, the policy agreed by these managers and workers must take into account the feelings of all the people whom they represent. This, in turn, means that there is no question of passing important measures of policy by majority voting, for by so doing the proper and legitimate interest of the consumer, or of a particular type of worker, or of a particular type of manager, might be left completely unsatisfied, if the other interests in combination produced a majority vote. These important decisions, must to a major extent, fulfil the legitimate desires of all who are concerned in the effects of those policy agreements. This, in turn, suggests that terms of reference of such a policy-making body must be that they may only make new policy when all members of the joint body are in agreement. It also suggests that there be present at such meetings not only people responsible for representing workers, but also people responsible for representing supervisors, managers, technicians, consumers and shareholders.

The second part of the job of management, which is the execution of policy, must be delegated exclusively to managers by the policy-making body.

When we talk of policy decisions, we are apt to think of the very important decisions made at high level. But policy decisions are being made continuously at all levels of a factory. A section supervisor in charge of a group of twelve operators has the job of deciding which operators should do which jobs from amongst those that keep arriving on his section from time to time. In making these decisions he is implementing some policy, which he may have decided arbitrarily. Such a policy may be perfectly satisfactory to those concerned and will not require discussion until it produces friction. But suppose that the supervisor implements a policy of giving the best jobs to the "blue-eyed boys" then we all know that he will create serious dissatisfaction. When dissatisfaction breaks surface, that policy can become the subject of discussion between workers and the section supervisor, who, in this instance, will have to represent not only other managers, but other interests, too. Having decided what is a fair policy, then those twelve operators must, if the supervisor is to be able to do his job, delegate the carrying out of that policy to him. He must operate that policy until either he or his workers challenge it. That section supervisor will gain a new status or perhaps a new kind of authority, of a type acceptable to those twelve operators.

To sum up, it seems that we require :

(*a*) To develop the new industrial situation so that both managers and workers find themselves able to shoulder and carry out their respective responsibilities.

(*b*) To make possible the deciding of policy which takes into account all the relevant facts and which reflects the feelings, opinions and interests of all concerned, including consumers, shareholders, managers, technicians, workers, trade unions and the nation at large.

Fear of Arbitrary Decisions

Mention has already been made of the autocratic framework within which industry operates. While the directors have at law the right to make nearly all policy decisions, there are now many laws which make gross decisions illegal, and certain aspects of other interests are protected to quite a large extent (e.g., by the Factory Acts, Truck Acts, &c.). Also, full employment results in an increased measure of security so far as the worker is concerned. But in spite of all this, is it not agreed that many people fear being subject to arbitrary decisions without appeal ? Is not this one of the most serious problems standing in the way of increased productivity ? Why is this ? Here is a possible explanation.

Much of our own behaviour, and the behaviour of other people, is quite inexplicable in conventional terms. Either we must believe that human beings are poor stuff, and explain what happens by believing in "original sin," or some such doctrine, or we must seek more satisfying explanations by working out new theories about behaviour which fit the evidence of our own experience. Here is one theory which fits at least some of the facts, and may have value. "There is a prevalent subconscious feeling amongst those who work in industry, and, indeed, amongst most people, which, if brought to the surface and expressed in words, would sound something like this : 'We find it impossible to approve of, or to be enthusiastic about a situation which results in those having authority over us consistently attempting to do things to us or for us, and the fact that these people may have the most benevolent intentions does not eliminate our objections to the process. In a society which calls itself democratic we think it fair to expect others to do things with us, instead of to us or for us.'"

Perhaps housewives feel this about industries which suddenly increase the price of goods they buy. Workers and supervisors feel this about higher management that launches schemes and plans without discussion and agreement. Managers feel this about boards of directors, who plan changes of product or organisation without reference to them. Directors feel this way about Government departments who apparently arbitrarily increase or decrease the price or availability of vital materials without getting their views. Technicians feel this way about executives who don't seek their advice on processes concerning which they are experts. Supervisors feel this way about technicians who design machines and processes without the comment of those who have to do the actual job. Managers and the public feel this way about trade unions who force wage awards which result in higher prices.

All that has been said may seem to be very remote from the problem of productivity, and this is precisely the difficulty. Our current approach regards discussions of this sort as having little to do with productivity, but until we begin to associate consideration of these sort of problems with the problem of productivity I do not think we shall be able to achieve the national volume of output which is required.

Strife for Power

May I pose one more way of looking at the problem which I believe to require scientific investigation ? The group which has the greatest power position can, and often will, without discussion, dictate what shall be done to other groups. Because of this, every person or group is driven to seek power in order to control other people and the situation as a means of self-protection. This, in origin, is the reason for the formation of trade unions, foremen's associations, employers' federations, some professional associations, ratepayers' associations, the Housewives' League, the British Legion, the Scottish Nationalists, &c. This may be the reason why many people who may possess

no personal respect for a particular political philosophy follow extreme leadership, so long as it appeals to them as the quickest way to bring about a change in the disposition of power. This may be the reason why peaceful people elect bellicose leaders, for they feel that only such leaders are capable of the fighting conduct that is necessary to overcome the power of the group which is imposing its will upon them. Unless means are worked out whereby individuals and groups can find ways of settling their differences without the use of power, and unless the situation can be so changed that people don't live in fear of the power of others over them, then our present difficulties and tensions will increase. People preoccupied with problems of this sort, whether they be managers, workers or technicians, are unable to apply to the problems of productivity the attention which is required to-day.

Sociological Research for Productivity

It seems to me, therefore, that in addition to the large volume of varied technical work and research which must go on if we are to achieve higher productivity, certain other measures are also required, and these other measures themselves require scientific research. My own current, unsupported opinion can be summed up as follows. We require :

(1) Generally, to develop the new industrial situation so that both managers and workers find themselves able to shoulder and carry out their respective responsibilities.

(2) Particularly, to make possible the deciding of policy which takes into account, first, the facts, including details of any higher policy to which discussions must defer, and secondly, the feelings and interests of all concerned, including consumers, shareholders, managers, technicians, workers, trade unions and the nation at large.

(3) To provide means as required for the foregoing by establishing bodies for formal discussion, and so constituted that any member may raise any matter for discussion thereby :

(i) To build up agreed policy in such a form as to make it possible and easy to delegate to the executive members of the consultative bodies the duties and responsibilities of implementing that policy.

(ii) To revise from time to time the functions and the jobs of both management and worker in such a way as to relieve workers and others of their prevailing fear of having things done to them.

(iii) To provide for or decide upon machinery for settling differences by discussion.

(iv) To provide a pattern for the spontaneous discussion of any matter that people feel is of concern to them in their industrial role.

These, I think, are the sort of theories which, in addition to the technical approach, require research and, if validated, application, if we are to meet the problems of productivity which beset us. May I end as I started ? If by some such approach we help productivity, we shall, I think, have aided also the solution of most other industrial problems.

Helicopters.—It is announced that, with the agreement of the Ministry of Supply, arrangements have been completed between the Cierva Autogiro Company, Ltd., and Saunders-Roe, Ltd., for the latter company to take over the development of current designs of Cierva helicopters. The Cierva Autogiro Company, Ltd., will continue on helicopter research, and its temporary address is c/o Saunders-Roe, Ltd., Southampton Airport, Eastleigh, Southampton.

Notes on Magnesium Alloys

By F. A. FOX, D.Sc., M.Sc., F.I.M.

No. I

IT is obvious that engineering materials which combine lightness with strength are attractive to the designer. What light metallic materials are available ? Eliminating such unlikely metals as sodium, calcium, potassium, there are four which attract serious attention. These are aluminium (specific gravity 2·699), beryllium (specific gravity 1·82), magnesium (specific gravity 1·74), and titanium (specific gravity 4·54). The alloys of aluminium are already well known and have been much described ; beryllium is usually regarded as a metallurgical disappointment, and for most purposes has proved to be so. Titanium, with its melting point of about 1815 deg. Cent., seems a likely candidate for high-temperature resistance where lightness is also required, but is still in the experimental stage. In this discussion, the properties and present status of magnesium alloys will be described.

Magnesium is 40 per cent lighter (less dense) than aluminium ; its melting point is 650 deg. Cent., and its boiling point about 1110 deg. Cent. Its coefficient of expansion is 26 micro-inches per inch per deg. Cent., and its modulus of elasticity $6{\cdot}5\times10^6$ lb per square inch.

It is, like most other metals, weak and soft in the pure state, but it alloys effectively with aluminium, zinc, manganese, tin, zirconium and cerium. These elements are the ones which in recent years have been used in the engineering alloys.

Production

The starting point for the manufacture of magnesium is usually the oxide, magnesia, obtained either from the calcination of the naturally occurring carbonate, magnesite, or by extraction from sea-water. A cubic mile of sea-water contains 4 million tons of magnesium, and the Dead Sea alone contains enough magnesium to maintain for thousands of years the highest world production ever recorded.

Magnesia is converted into magnesium either indirectly, by being first converted into the chloride and then electrolysed in a fused salt cell, or directly by reduction with suitable reducing agents under suitable conditions. The reducing agents most favoured are silicon as ferrosilicon or carbon. In the carbon process the reactants are heated to a temperature above 2000 deg. Cent., and the gaseous products magnesium vapour and carbon monoxide are shock cooled with hydrogen to avoid reversal of the reaction, which occurs at lower temperatures. The ferrosilicon or Pidgeon process is operated in a high vacuum at about 1150 deg. Cent. During the war the peak total production capacity in the U.S. was divisible by processes into 72 per cent electrolytic, 4 per cent carbothermic and 24 per cent ferrosilicon.

The world's productive capacity was enormously increased during the war, and the U.S. productivity for magnesium was increased 100 times between 1940 and 1943. One result has been the accumulation of enormous stocks of magnesium, and at present many plants are not operating, since the existence of stocks equal to many years' peacetime consumption makes it uneconomic for them to run. Nothing is known of the position in the U.S.S.R.

Properties and Behaviour

Cast Alloys.—Magnesium alloys are known by many proprietary names ; in this country those best known are the Elektron series, made by Magnesium Elektron, Ltd., of Manchester. In the U.S. the best-known brand is the Dowmetal range, made by the Dow Chemical Company.

The alloying element zirconium has only very recently been successfully and reproducibly introduced into the magnesium alloys available in this country. Its great attraction is that it has an intense grain refining action and, as a result, has a beneficial effect in the direction of increased strength and uniformity of the alloys. From this also follows a much closer relation between the strength of a casting in all its parts (as tested by pulling test bars cut from places of interest in the casting), and the strength of the separately cast test bar, which is taken to represent a casting or batch of castings. This naturally makes for greater reliability.

The alloys containing zirconium are used in combination with zinc or with cerium. With the former a valuable general casting alloy can be made, capable of improvement by heat-treatment and, with the latter, a useful casting alloy for use at elevated temperatures (up to 200 deg. Cent.) is formed. With both these types of zirconium-containing alloys, the zirconium content does not exceed about 0·75 per cent and is usually of the order of about 0·70 per cent ; this concentration is, however, enough to ensure the formation of the fine grain size mentioned above.

The range of casting Elektron alloys as used in this country, their approximate compositions and their average mechanical properties are given in Table I, which includes also the new zirconium-containing alloys.

The average D.T.D. test bar figures shown for the magnesium-aluminium-zinc alloys are regularly obtained only where the alloy has a reasonably fine grain.

From this table it will be seen that aluminium and zinc are the principal alloying elements in the older standard range of alloys, and that additions of about 0·3 per cent manganese are also made. This element has an important effect on the corrosion resistance of the alloys. Where the alloys contain no manganese their corrosion resistance decreases with increasing aluminium content. When a manganese content of more than about 0·15 per cent is present, the corrosion resistance slightly increases with increasing aluminium content. The effect of manganese on the mechanical properties is small.

Magnesium-aluminium alloys show a maximum in the tensile strength curve at about 4½ per cent aluminium, and this alloy, when sand cast, has a strength of about 12 tons per square inch ; its proof stress is, however, low (about 3 to 3½ tons per square inch), and its casting characteristics are not so satisfactory as for those in the Elektron range indicated in Table I ; moreover, it is sluggish, and tends to " sink " locally.

The addition of small amounts of zinc has a slightly beneficial effect on the castability of the magnesium-aluminium alloys, and the elongation as cast may be somewhat improved. The addition of zinc above about 0·75 per cent, however, appears to affect

adversely the soundness of the casting, in that there is a greater tendency to microporosity.

With the zirconium-containing alloys, aluminium is not compatible as a third alloying addition; only zinc and cerium have been found useful to help increase the strengthening effect of the zirconium.

Table I—*Standard Magnesium Casting Alloys at Present in Use*
(As cast; without heat-treatment)

Alloy				Average tensile properties		
Nominal composition, per cent	D.T.D. specification	Elektron designation	Condition	0·1 per cent proof stress, tons/in²	Ultimate stress, tons/in²	Per cent elongation on 2in
Mg+8 Al +0·4 Zn +0·3 Mn	59B	A8	Sand cast	5·3	10·5	3·0
Mg+9·5 Al +0·4 Zn +0·3 Mn	136B	AZ91	Sand cast	5·0	9·6	1·5
Mg+8 Al +0·4 Zn +0·3 Mn	59B	A8	Die cast	5·8	14·0	8·0
Mg+9·5 Al +0·4 Zn +0·3 Mn	136B	AZ91	Die cast	6·0	12·5	3·0
Mg+4·5 Zn +0·7 Zr	711	Z5Z	Sand cast	7–8·5	13–17	7–15
Mg+2·5 Ce +2·5 Zn +0·7 Zr	Pending	ZRE1	Sand cast	5–6	9–11	3–6

Magnesium alloys, unlike many aluminium base alloys, have no serious gas problem. They are, however, in common with other casting alloys, liable to be microporous if certain elementary precautions are not taken. This microporosity, which takes the form of concaved-sided voids, when present in a severe form due to faulty casting conditions, may have a great effect on the mechanical properties, and the ultimate tensile stress may be reduced by 50 per cent; where microporosity does occur the proof stress appears to be affected to a less extent than do the ultimate stress and elongation.

Microporosity can fairly readily be detected on thin section (up to ¼in thick) by X-ray examination, as well as by fracture testing (it appears as a dark stain in the fracture), and in this way a control over the maintenance of correct casting methods for new jobs is facilitated. The "lakes" of microporosity appear to be disposed normally to the direction of solidification. With proper founding technique what microporosity does appear in a casting is confined to the risers, which are cut off and remelted.

The alloys containing aluminium and zinc were formerly treated for grain refinement by a process known as superheating, i.e., the molten charge was taken to a temperature of about 900 deg. Cent., cooled rapidly, and then poured at the usual pouring temperature of about 750 deg. to 780 deg. Cent. This process has now been superseded by the addition of about 0·05 per cent of hexachlorethane, which produces the grain-refining effect at a temperature of only about 780 deg. Cent. For the magnesium-zinc-zirconium alloys, no superheating or carbon compound treatment is required, since the zirconium itself ensures the grain refinement.

Wrought Alloys.—In this country the magnesium alloys used in the wrought state are: an alloy containing 6 per cent aluminium, 1 per cent zinc and 0·3 per cent manganese for extrusion; one containing about 8 per cent aluminium, 0·4 per cent zinc, and 0·3 per cent manganese for forging, while an alloy used for rolling consists of the binary magnesium-manganese alloy containing about 1·5 per cent manganese. The new alloys containing zirconium and zinc are also coming into use as sheet, forgings and extrusions, which give enhanced properties and ease of working (see Tables II and II*a*).

Sheet.—An interesting development of the past few years in this country has been the rolling of sheet alloys directly from cast slab. It was thought for many years that no magnesium alloy could be satisfactorily rolled without the initial stage of extrusion. The practice used to consist of extruding a billet about 12in in diameter into the form of a "blank" about 1¼in thick. This was then hot rolled with various reheatings to a thickness near the finished gauge, the last few thousandths of an inch reduction in thickness being made cold. By producing a slab under carefully controlled casting conditions, the manganese and the zirconium-containing alloys can now be rolled direct, and the mechancial properties of the finished sheet are as good as those of the same alloy which has been extruded as well as rolled.

A further point about the magnesium-manganese and other magnesium base alloy sheet is that any directionality which occurs is not in the usual sense. All the properties are higher in a direction at right angles to the principal rolling direction than in the longitudinal direction. Where the rolling reductions are correctly applied, and reheats properly spaced, the actual amount of this directionality is small. In improperly reduced sheet the directionality can be large, the following being an example of the difference between the two directions:—

Mg-Mn alloy sheet, direction of test	0·1 per cent proof stress, tons/in²	Ultimate tensile stress, tons/in²	Per cent elongation on 2in
Longitudinal	7	14	6
Transverse	9	16	10

This directionality is connected with the crystal orientation of the sheet. Both hot and cold rolling produces an orientation of the crystals with the basal plane (0001) parallel to the plane of the sheet. This orientation is never perfect, and it has been found that there is a certain amount of scatter of the basal planes which appears to be greater in the longitudinal than in the transverse

Table II—*Wrought Magnesium Alloys in Current Use*
(Standard Alloys)

Alloy				Average tensile properties		
Nominal composition, per cent	D.T.D. specification	Elektron designation	Condition	0·1 per cent proof stress, tons/in²	Ultimate stress, tons/in²	Per cent elongation on 2in
Mg+1·5 Mn	142A	AM503	Extruded bar	8–13	15–20	4–10
Mg+1·5 Mn	118A	AM503	Sheet	6–10	13–18	5–14
Mg+1·5 Mn	737	AM503	Extruded tube	8–10	15–17	4–6
Mg+6 Al +1 Zn +0·3 Mn	259A	AZM	Extruded bar	11–14	16–22	10–18
Mg+6 Al +1 Zn +0·3 Mn	88C	AZM	Forging	10–13	18–20	8–14
Mg+6 Al +1 Zn +0·3 Mn	348A	AZM	Tube ... ...* ...	9–11	17–20	8–12
Mg+8 Al +0·4 Zn +0·3 Mn	88C	AZ855	Press forgings	11–14	18–22	8–14

Table II*a*—*Wrought Magnesium Alloys in Current Use*
(Zirconium-Containing Alloys)

Alloy				Average tensile properties		
Nominal compositions, per cent	D.T.D. specification	Elektron designation	Condition	0·1 per cent proof stress, tons/in²	Ultimate stress, tons/in²	Per cent elongation on 2in
Mg+2–4 Zn +0·7 Zr	626	ZW3	Sheet	11–14	17–20	8–18 (or 6T cold bend radius)
Mg+2–4 Zn +0·7 Zr	733	ZW3	High strength extrusions not greater than 3in	17–21	23–26	8–14
Mg+2–3 Zn +0·7 Zr	Pending	ZW2	Extruded tubes	11–15	17–22	3–8
Mg+2–4 Zn +0·7 Zr	619	ZW3	Press forgings	13–15	19–22	8–14
Mg+2–4 Zn +0·7 Zr	729	ZW3	Impact forgings ...	11–14	17–20	8–12

direction; this accounts for the lower proof stress in the longitudinal direction.

This magnesium-manganese sheet can be welded very satisfactorily with the oxy-acetylene torch, and ultimate tensile strengths of well over the A.I.D. requirements of 8 tons per square inch can be obtained across an unhammered weld. The magnesium-zinc-zirconium alloy must be welded with the argon-arc process; it is not amenable to gas welding.

It is essential to use a suitable flux for the gas welding of magnesium alloys sheet and tube, and this usually contains some constituent which acts as a solvent for, or which in some way absorbs, magnesium oxide. It is also desirable to avoid the use of a flux containing sodium salts, since they tend to cause obscuration of the work by their intense colouration of the flame.

The sheet alloys will successfully permit simple forming operations at room temperature, while severe forming or drawing is applied at a temperature about 350 deg. Cent. At this temperature directionality effects are not important and the sheet is readily workable, having great ductility in a wide plastic range. The temperature for hot working the sheet is not critical so long as it is reasonably well above the temperature of about 225 deg. Cent., and as long as the temperature is not so excessive as to cause rapid grain growth. The temperature of 225 deg. Cent. is that at which in pure magnesium a new set of slip planes becomes operative, and greater ductility is conferred on the material. This temperature is probably approximately correct also for the magnesium-manganese alloy. Grain growth does not occur until temperatures much in excess of 400 deg. Cent. are reached. The tendency to grain growth following "critical" cold work, although present in pure magnesium sheet, is much reduced by the presence of the manganese in the alloy.

The cold bending radius which can safely be put on the manganese-containing sheet alloy is approximately 5T, although the zirconium-containing alloy may behave slightly better still, with a bend radius of 4T.

Extrusion

A large amount of section and tube is extruded in the 6 per cent aluminium, 1 per cent zinc, 0·3 per cent manganese alloy (Elektron AZM). They are used, for example, for the fabrication by welding of seats in aircraft, and generally for the manufacture of various aircraft components and as "stock" for forging.

This alloy is satisfactory for general purposes as far as the extrusion process is concerned; it has a moderate aluminium content (the higher the aluminium content the lower is the extrusion speed), while the presence of 1 per cent zinc has a slightly beneficial effect in assisting corrosion resistance. Extrusions in this alloy are not quite so strong as would be those with a higher aluminium content, but the cost advantage of greater extrusion speed, which is possible because of the lower aluminium content, more than counterbalances the disadvantage of the slightly lower strength. The new alloys containing zirconium can be extruded very rapidly and give high mechanical properties, as shown in Table II*a*. The alloys are, however, sensitive to extrusion temperatures and speeds and can be controlled in properties accordingly; the highest strengths result from lowest temperatures and speeds.

Forgings

In the older aluminium-containing alloys, there are two compositions in use for forgings—extruded Elektron AZM stock and Elektron AZ855, which is the 8 per cent aluminium, 0·4 per cent zinc, and 0·3 per cent manganese alloy. Although this latter alloy will not extrude rapidly, it is sufficiently workable at temperatures between 350 deg. and 400 deg. Cent. to be readily die forged or pressed, and it is capable of being hot swaged. The forging pressures required for small components are lower than those for corresponding parts in aluminium-base alloy. High pressures are required for forging large components, since it is important to ensure that the work shall penetrate the whole piece and shall not be confined to the surface layers.

The mechanical properties of forgings with even higher aluminium contents than 8 per cent would be slightly better from the point of view of proof stress and ultimate tensile stress, but would be distinctly inferior from the point of view of percentage elongation. For this reason more highly alloyed materials are not used in forging.

Although for the greatest uniformity of properties and for the highest test figures it may be desirable to forge extruded blanks, it is nevertheless readily possible, and in some cases even preferable, to forge cast blocks in this 8 per cent aluminium alloy. The forging must be carried out relatively slowly, hydraulic pressure being the most satisfactory. The piece is also usually turned through 90 deg. in successive operations, in order to ensure reasonably uniform distribution of the hot work and to avoid the production of excessive directionality. Forged components can be made in this alloy to resist large hydraulic pressures: for example, a hydraulic cylinder was made during the war, the finished wall thickness of which was only $\frac{3}{16}$in, and the internal test pressure was 4000 lb per square inch.

The new zirconium-containing alloys are hot worked much more rapidly, and are not only capable of being forged from cast pieces; they can also be forged under the drop hammer, and do not need hydraulic equipment. The mechanical properties of these forged alloys are good, as Table IIa shows.

(To be continued)

Metropolitan Water Board

WORKS IN PROGRESS AND CONSTRUCTED IN 1950

In our issue of January 27th, 1950, reference was made to the two main problems confronting the Metropolitan Water Board—the provision of adequate storage reservoirs for the maintenance of the supply in times of drought, and the construction of sufficient filtration plant to ensure the purity of the supply. Investigations are still proceeding in connection with the Board's proposals to construct further large storage reservoirs in the Thames Valley. Increased filtration capacity will be provided immediately—to a minor extent—by the four new filter beds at Walton, but the addition of the 90 m.g.d. plant now under construction at Ashford Common should provide in about two years' time a substantial margin over immediate requirements.

The proposed 75in raw water main to convey Thames water to the valley of the River Lee would make good the failing supply from that source and increase the yield from the reservoirs in the Lee Valley, but the full use of this main is dependent upon the provision of adequate storage in the Thames Valley, which is the key to the whole of the London water supply.

An Experimental Tunnel

An interesting development in the lining of small diameter tunnels driven in London clay is taking place at Stoke Newington, where an experimental length of tunnel is being driven for the Board as the first part of the construction of the raw water main referred to above. The Board is faced with the necessity of laying the 75in diameter main across London for a distance of some 22 miles, and in order to overcome the difficulties of laying such a main in the heart of London, its consulting engineers for this work, Sir William Halcrow and Partners, proposed that it should be laid in tunnel. The normal method of laying such a main in tunnel has been to provide a tunnel of sufficient diameter to carry one or more pipes in the invert. This method involves the driving of a tunnel of much greater diameter than is needed for the conveyance of water, so that the scheme proposed in this case is to drive a tunnel of a diameter sufficient only to enable the 75in pipe to be drawn through it. The pipe will then be jointed internally and the small annular space between the pipe and the tunnel lining will be filled with concrete.

Since in a system of this description the tunnel lining will be merely a temporary measure, which will ultimately become a part of the main, a more economical lining than the usual bolted segments was sought. Use has therefore been made of a new method, devised by Mr. H. L. Donovan, employing precast, unreinforced concrete segments. This system was developed by the contractors, Kinnear Moodie and Co., Ltd., as part of the experimental contract which they are carrying out for the Board, and it is of interest to note that

Experimental Tunnel—Shield Rams Extended from Erected Lining

so carefully was the experimental work carried out that the first rings of these segments were, to all intents and purposes, perfect.

The tunnel is being driven to a diameter of 8ft 6in in London clay by means of a shield with ten hydraulic rams. The concrete segments are 6in thick and unreinforced. The width of each ring is 21in and there are ten segments per ring. Each segment is wedge-shaped in plan with radial longitudinal joints and all segments are interchangeable. The length of each segment is 34½in, tapering to 29½in, measured on the outside circumference.

After excavation of the clay the shield is shoved forward, leaving a sufficient gap between the shield and the last ring to allow the setting of the next ring, as shown in the first illustration.

The segments, which can be moved by two men and lifted by four, are then laid, starting from the invert and building alternate sides to complete the ring. This stage of construction is shown in the second illustration.

Those segments having the longer end of the wedge leading are left with about 4in leading from the segments laid in the opposite direction, so that the diameter of the erected ring is less than the finished diameter and a gap is left in the crown of sufficient size to allow the final segment to be placed. The segments forming the arch are supported in position by steel pins inserted into the rams of the shield and also by timber wedges held by a temporary steel channel ring erected inside the last completed ring, as shown in the third illustration.

EXPERIMENTAL TUNNEL—EMPLACEMENT OF LOOSELY STEPPED SEGMENTS OF RING

COMPLETED LENGTH OF EXPERIMENTAL TUNNEL

On completion of the building of the ring the female segments are pushed hard against the last completed ring by their respective rams and when the pressure has been removed from these rams the male segments are then driven forward in succession by their rams to their final position. As each segment moves forward the ring expands and the final segment brings the ring to the exact diameter, bearing tight against the clay and the last completed segment.

The whole operation of building a ring occupies, on an average, only fifteen minutes. With two gangs working twelve-hour shifts on five days a week, a regular advance of 70ft has been maintained without difficulty. This progress is achieved by each gang having a task of four rings per shift.

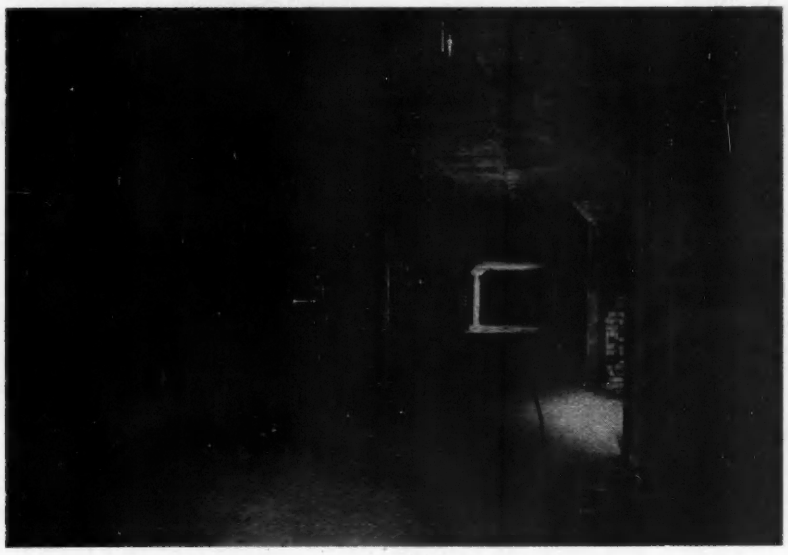
The final lining is almost exactly to specified diameter, the greatest variation recorded so far being ½in. Correction for line and level is easily achieved by the insertion of wooden packings of the desired thickness. The cost of the work is not yet ascertainable, but the indications are that there will be a considerable saving over the method employing bolted segments. The present tunnel is an experimental one and if it proves successful it will be incorporated as part of the whole scheme when this is proceeded with.

Works in Progress in 1950

Turning now to the other works of the Board in progress in 1950, it will be recalled that the extensive scheme for a filtration works and pumping station at Ashford Common, with a capacity of 90 m.g.d., was described and illustrated in our issue of January 27, 1950, page 127. The whole of the civil engineering work is being carried out by John Mowlem and Co., Ltd., under two contracts, the first of which includes approximately one-half of the installation and the pumping station.

Fourteen of the first sixteen filters have been completed and the other two are being sanded. Concrete work for the sixteen filters in the second half of the installation is also substantially complete and the laying of the porous underdrains has been started. Work continues on the main walls and columns of the east contact tank and the construction of the reinforced concrete roof is in progress. Work has also been commenced on the contact tank on the west side of the installation and the construction of two sand-washing and storage bays is also proceeding. Foundations for the engine-house have been completed and the suction conduits are being placed in position. The constructional steel framework has been erected and work has been commenced on the concrete floors and roof of the main building.

Barnes and Chingford.—The construction by McLaughlin and Harvey, Ltd., of a concrete contact and balancing tank at Barnes Works was completed and the tank was under test by the end of the year. The tank has a total capacity of 4½ m.g. and is divided into two compartments. The interior of the tank, showing the perforated baffle wall, may be seen in the illustration reproduced herewith. This scheme also provides for electrically driven low-lift pumps to lift the water into the contact tank and their manufacture has been completed. A new pump house is being built by Grace and Marsh, Ltd., and chemical treatment plant is now available for installation.



INTERIOR OF CONTACT TANK AT BARNES

The new storage reservoir at Chingford, when completed, will have a capacity of 3400 million gallons. During the past year the raising of the embankment, together with the core wall, was finished and considerable progress was made on the concrete lining to the inner slopes of the reservoir, which was almost completed. An order has been placed for electrically driven pumps, which will be automatically started and stopped and controlled by the river flow. The pumps will normally run unattended. The accompanying

illustration shows the slab lining and the outlet tower and bridge of the reservoir.

Fortis Green.—In order to increase the standby margin and safeguard the heavy demand of water from this station, the Board decided to extend the existing pumping station and to install additional electrically driven centrifugal pumping plant. Building work was commenced by Thomas and Edge, Ltd., in March last and brickwork is nearly up to roof level. All the machinery has been delivered and a 42in suction main laid from the reservoir to the pumping station, a distance of 376 yards.

OUTLET TOWER AND BRIDGE—CHINGFORD SOUTH RESERVOIR

Hampton.—In the issue of January 21, 1949, reference was made to the remodelling scheme, whereby the capacity of these works has been increased from about 55 to 120 m.g.d. The original scheme is now complete, apart from the new raw water pumping station at Sunnyside, a new chlorinating house, roads and garden lay-out, and a central sand store and sand-washing plant.

Manufacture is proceeding of the pumping machinery for Sunnyside, which will be driven partly by surplus water power, and the contract of F. R. Hipperson and Sons, Ltd., for the new building is nearing completion. The tender of W. H. Streeter, Ltd., for the construction of a new chlorination house was accepted and site work is about to start. Designs are being prepared for the new sand store and plant required.

The reconstruction of twenty-nine low-level slow sand filter beds by direct administration was commenced in May, 1947, and a further bed was completed during the past year, making a total of five beds reconstructed.

Lee Bridge.—The interim scheme at these works was almost completed by the end of 1950 and the plant was in operation. Subject to the approval of the Ministry of Health, the Board has decided to carry out further improvements to this works, including adaptation of the old buildings, the provision of a central sand-washing store and the construction of new roads and pavements. During the past year the banks of the aqueduct, which conveys stored water to this works, were raised by the construction of a concrete flood wall by W. and C. French, Ltd.

New River Mains.—In January, 1950, the Board's pipe-laying contractors, William Press and Son, Ltd., commenced taking up the disused New River mains between Stoke Newington and New River Head and the work is now completed.

60in Trunk Main—Kempton Park to Cricklewood.—This main when completed will have a total length of 13¾ miles and will convey additional Thames water to North-West and North London. The main-laying contractor, J. B. Edwards and Co. (Whyteleafe), Ltd., has finished Section No. 1 from Kempton Park to Wesley Avenue, apart from one connection, and the contract of the Cementation Company, Ltd., for Section No. 2, from Wesley Avenue to Lyndhurst Avenue, is approaching completion. In June last J. L. Eve Construction Company, Ltd., commenced main-laying work on Section No. 3, from Lyndhurst Avenue to Abbey Avenue and 2004 lineal yards have now been laid out of a total length of 7007 lineal yards for this section of the main. The contract document is being prepared for the fourth and last section of the main, Abbey Avenue to Cricklewood.

Walton.—The four additional slow sand filter beds at Walton, having a total area of 3·28 acres, were completed by John Mowlem and Co., Ltd., in June, 1950. Two additional electrically driven raw water pumping units are on order, which will reduce the load factor of the existing steam units. In June, 1950, work was commenced by J. Jarvis and Sons, Ltd., on the construction of a concrete contact and balancing tank of approximately 2½ m.g. capacity. The floor has been laid and the mass concrete walls are about 56 per cent complete.

General.—During 1950 a second 24in diameter bore-hole was completed to a depth of 384ft at Horton Kirby, in Kent, and work also commenced on the sinking of an additional 24in diameter bore-hole at Lullingstone, previously called Shoreham. Schemes for the replacement of obsolete steam-driven plant were carried out at Cricklewood, Stoke Newington and Wilmington, and are in hand at Hammersmith, Campden Hill and other stations.

New schemes approved by the Board included the provision of standard low pressure and high pressure contact tanks at seventeen of the Board's well stations; concrete contact and balancing tanks at Hornsey, Kew Bridge and Stoke Newington; the laying of 24in, 18in and 12in mains for the improvement of supplies in the Knockholt reservoir zone, and 30in, 24in, 20in and 12in mains, Eynsford and Horton Kirby to Bickley, and the construction of a 5 m.g. service reservoir at Knockholt.

The Testing of Motive Power Machinery*

By T. W. F. BROWN, D.Sc.

No. I

HAVING been honoured by the invitation of your Council to deliver this year's Watt Anniversary Lecture, I propose to deal with a subject which had its beginning in the work of James Watt, namely, full-scale testing of motive power machinery used to transform heat energy into work.

Watt can be said to be the father of full-scale testing of motive power machinery. His experiments with the model of the Newcomen engine repaired by him at Glasgow University showed that a scaled-down model did not give practical results. The surface area of the cylinder in this model being large in relation to volume, the cooling effect of the walls on the small quantity of steam admitted per stroke prevented it from operating continuously. Small models of heat engines have the same defect due to scale effects to this day. Therefore, in endeavouring to test his invention of the separate condenser, Watt did not rest until he had built a full-scale steam engine. This was the engine first built at Kinneil, and subsequently erected at Birmingham. Watt made many tests from 1774 until his retirement in 1800. His passion for measuring results with as much accuracy as was possible at the time set him head and shoulders above contemporary engineers. Although James Watt had a number of good assistants, he preferred to do most of the development work himself. Organised research with an integrated team is a much more recent development brought about by the increase in specialisation which has inevitably accompanied the growth of science.

The number of full-scale tests which have been carried out from that time to the present day is legion, and, therefore, in order to study the developments that have taken place it is proposed to consider only some typical tests at intervals of about fifty years, starting with the year 1800.

1800

This is a convenient date to examine the steam machinery developed as a result of full-scale tests for use as a prime mover in mining, mills and factories, as it was the year in which Watt gave up active participation in the firm of Boulton and Watt.

For the expenditure of 1 "bushel" (84 lb) of Newcastle or Swansea coal the Watt steam engine would then perform the following duties:—

(Boulton to James Watt, junior, November 28, 1796).

"(1) Will raise 30 million pounds of water 1 foot high.

"(2) Will grind and dress 10 or 11 or 12 bushels of wheat according to the state of it.

"(3) Will turn 1000 or more cotton spinning spindles per hour.

"(4) Will roll and slit 4 cwt of bar iron into small nailor's rods.

"(5) Will do as much work per hour as ten horses."

The accuracy of measurement in the early trials was not great, but it was sufficient to show that the improvements that Watt introduced raised the "duty" of steam engines ("duty" is the number of pounds weight of water raised 1ft by the consumption of 1 bushel of coal) by about four times.

Coal could be weighed as Wyatt had invented a bridge-weighing machine in 1743, and there were two public weighbridges in use in Birmingham within a few years of this date. It was, however, usually measured by volume in bushels. However, even the value of capacity of the bushel varied in different localities and produced considerable variations in the results of trials. In addition, a bushel of Pontop coal

* James Watt Lecture, Greenock Philosophical Society. Abstract.

weighed 91 lb, the usual figure for Tyne coal being 84 lb, and for Cornwall 94 lb.

The firm of Boulton and Watt built up their reputation as machinery contractors with pumping engines. Their income was largely affected by the "premiums" paid on the fuel savings made by such engines. Tests were, therefore, important to establish what the saving in fuel costs was compared with results from other contemporary engines. Such tests involved the measurement by volume of the coal burned in relation to water pumped. The

TABLE I

Engine	"Duty"	Corresponding modern criteria	
		Lb. coal/h.p.-hr	Thermal efficiency
			Per cent
Newcomen	$5 \cdot 5 \times 10^6$	30	0·62
	to $7 \cdot 5 \times 10^6$	22	0·92
Watt ...	$1776 : 21 \cdot 5 \times 10^6$	7·8	2·6
	$1780 : 26 \cdot 5 \times 10^6$	6·3	3·2
	$1796 : 30 \cdot 0 \times 10^6$	5·5	3·7

pump displacement multiplied by the number of strokes was usually taken as measuring the water quantity, although on at least one occasion the water was measured by volume and the correction factor (between the weight of water related to the displacement of the pump and that actually raised) of 0·92 obtained. This, incidentally, is a good figure for the volumetric efficiency of the pump and shows that the water valves were of ample area and tight.

In one experiment it was found that the time to raise steam in the boiler from lighting of the fire was 2 h 55 min. A pressure of 3in mercury on the gauge was obtained in a further 15½ min, which rose to 9in mercury in 7 min more. The engine was run for 1 h 45 min at thirteen strokes per minute, and the steam used determined from the difference in levels of the boiler water. The evaporation was found to be 11 cubic feet for 120 lb of coal. This corresponded to a boiler efficiency of about 55 per cent. Later records on improved boilers showed 7 cubic feet for 56 lb of coal. Swansea coal was said by Watt to evaporate 11 cubic feet for 79 lb. The boiler efficiency corresponding to these figures is about 70 per cent, assuming that the boiler did not prime badly. This would still be considered good for coal-fired boilers without air heaters.

From some experiments on feed water consumed, Watt determined the volume of steam required per stroke and found it to amount to 11 cubic feet, whereas the volume of the cylinder was only 8·8 cubic feet. This gave a measure of loss by condensation and possibly water carried over by the steam, these being the first real measurements of the "missing quantity" so well known in reciprocating engines.

Early in 1776 condensation in the cylinder jacket of an engine was measured. In 1800 strokes made in 2 h 24 min, 625 lb of feed water were used and water condensed in the jacket was between 70 lb and 90 lb. The steam used in the jacket was reduced in later experiments to 23 lb when the outer wall of the jacket was well lagged. It may be remarked that experiments on steam jacketing of cylinders were still being actively carried out in 1900.

In 1781, experiments on expansive working were made which showed the improvement caused by the expansion of steam, although the low pressure in the boiler (up to 15in mercury gauge) used by Watt prevented large expansion ratios being tried, relative figures being 2640 strokes for four expansions and 2836 strokes for five expansions, other conditions being maintained constant.

In these experiments it is clear that the use of mercury gauges gave accurate readings of pressures. Thermometers of accuracy to within 5 deg. Fah. were used for temperatures. Coal was either weighed or measured by volume and feed measured either by change of level in the boiler or by volume in feed tanks. The water pumped was measured to about 10 per cent accuracy, coal to about 5 per cent, and the experiments would therefore be accurate between 10 and 15 per cent of the true values.

In 1800 no friction brake had been developed to absorb power and enable the testing of rotative engines to be carried out. Friction losses in such engines were deduced from trials of the Soho forge engine tried first with the flywheel and rotative mechanism in place and then removed, a pump being driven in both experiments from the engine beam. It was found that at twenty strokes per minute with the rotative motion in place, the consumption of coal was 0·28 cwt per hour, and without, 0·235 cwt, which gives a factor of 0·83 to cover for additional engine friction arising from the rotative mechanism.

In 1794 Watt invented the engine indicator which measured pressure within the cylinder continuously. It consisted of a small cylinder fitted with a piston loaded by a spring. When connected with the engine cylinder the variable pressure admitted to the indicator cylinder moved the piston up and down against the spring. A pencil was fitted to the piston-rod of the instrument and hence recorded the pressure. Paper fixed to a board against which the pencil pressed would then record the pressure levels provided the board was moved proportionally to the stroke of the engine at right angles to the line of action of the pencil. The board on which the paper was fixed was later replaced by a cylinder, but the principle remained the same.

The diagram produced gave a measure of work done per stroke for a given engine and when multiplied by the revolutions per minute the work done per minute or the number of "horses" the engine was producing. Thus was produced the valuable instrument to measure indicated horsepower still used in all reciprocating engine tests, whether of the internal combustion or steam type, except at high revolutions, when inertia forces introduce inaccuracies. In Watt's time the indicator would be reasonably accurate on the pressure side as a direct connection between plunger and pencil was used. The total pressure range would not exceed 30 lb per square inch, and, at the maximum speed of, say, thirty-five strokes per minute for a small engine and less for larger ones, the inertia forces in the stroke mechanism would be low.

We see therefore that by the year 1800 the measurement of engine power, and of overall economy in terms of the coal required to produce a given amount of work, were both well established, although the degree of accuracy obtained would not be very high, and only indicated power could as yet be measured.

The determination of the steam conditions at which an engine was working resolved itself simply into the measurement of the steam pressure and the vacuum, and in view of the low pressures used, both of these quantities could be measured quite accurately using mercury manometers.

We see also that the first rather crude experiments had been made to determine the effect of such factors as degree of expansion, cylinder condensation, jacketing and the like, on which so much effort was to be expended in the century that followed.

ENGINE TESTING IN 1850

No fundamental change had taken place in the methods of testing machinery since Watt's time, although improvements in detail no doubt increased the accuracy with which results could be obtained. For the measurement of power the engine indicator was still the only method available for engines of any size. The friction brake (or "Prony" brake) had been introduced in 1821, but was suitable only for small powers and, in the form in which it was then made, it tended to be unstable. Various modifications were put forward for overcoming the instability, but the brake was rarely used until Kelvin in 1858 introduced the now well-known form in which a flexible brake band, passing round the engine flywheel, is loaded by weights at one end and a spring balance at the other.

A spring torsionmeter had been constructed by Morin in 1841, and was demonstrated at the 1851 Exhibition, where it was used to measure the power absorbed by centrifugal pumps. A similar instrument had been used at sea, but a contemporary stated: "It is difficult to obtain true indications from this instrument which is liable to many disturbing influences." No satisfactory torsionmeter was, however, produced until the introduction of electrical methods of measurement over half a century later. The disadvantages of "mechanical" torsionmeters were, first, that it was difficult to bring out an indication of deflection from the rotating member to a stationary dial without introducing backlash, and, secondly, that to obtain a sufficiently large deflection for accurate measurement the spring members had to be relatively weak, and hence, with the reciprocating engines of those days, were affected by the large torque variations.

The belt transmission dynamometer was invented by Froude in 1856 for use in the competitive machinery trials held annually by the Royal Agricultural Society. These trials, incidentally, served a very useful purpose in focusing attention on engine economy and on the development of accurate and reliable apparatus for the testing of engines, although the engines concerned were quite small. Froude's dynamometer was fitted with a dash-pot to damp out vibration and an automatic recorder for the brake load, so that cyclical variations in load could be measured as well as the average value.

To obtain the overall economy of an engine it was usual by this time to measure the coal consumed by weight rather than by volume, and to state the fuel rate in pounds per indicated horsepower-hour. Calorific values of fuels were not as yet determined, but tests were often made using a standard type of coal, usually designated as "Welsh hand-picked." The concept of the thermal efficiency of a steam plant as the proportion of the energy supplied in the fuel that was converted into useful work, and also its separation into boiler efficiency, and engine efficiency, did not become familiar to engineers until some time after 1850. Indeed, at that time the necessary theoretical background was still being developed. For example, Joule was carrying out his experiments on the mechanical equivalent of heat, and although Regnault's determination of the properties of steam had been made in 1847, the results were not widely known amongst engineers, most of whom continued to believe Watt's Law that the total heat of steam was independent of pressure.

In the days of the jet condenser the steam consumption of an engine could not be determined by the measurement of the condensate, but after the introduction of the Kennedy water meter in 1854 the boiler feed water was occasionally measured.

Steam conditions were measured primarily to ensure the safe and proper working of the machinery, and the chief instruments used were as follows:—

Steam pressures were measured either with mercury manometers or, in the case of higher pressures, with gauges that depended for their action on the compression of a column of air. Diaphragm gauges were sometimes used, but were probably rather inaccurate owing to the small deflection obtainable from a diaphragm capable of withstanding the pressure. In addition, they were distrusted as liable to take up a permanent set, and so alter the scale zero, probably owing to the makers using too weak a diaphragm in an effort to obtain a large deflection. The Bourdon type of pressure gauge, which is now almost universal, was first described to the Institution of Mechanical Engineers in 1852, and appears to have gradually come into general use after this date. Its great advantage was the large movement obtainable from the Bourdon tube without overstressing the material.

Steam and water temperatures were measured with mercury-in-glass thermometers to a fairly high degree of accuracy, but there were as yet no reliable means of measuring higher temperatures, such as flue-gas or furnace temperatures. Thermometers consisting of a bulb and glass tube with a fine diameter bore were first used

at the beginning of the seventeenth century. Liquid thermometers were described in 1667 and improvements producing thermometers similar to those in present-day use were introduced by Martine in 1792.

Several types of mercury gauge were available for measuring condenser vacuum.

(*a*) The long vacuum gauge, which was similar to a mercury barometer, except that a connection from the condenser was led up through the inverted tube to the space above the mercury. The height of the mercury column gave a measure of the vacuum.

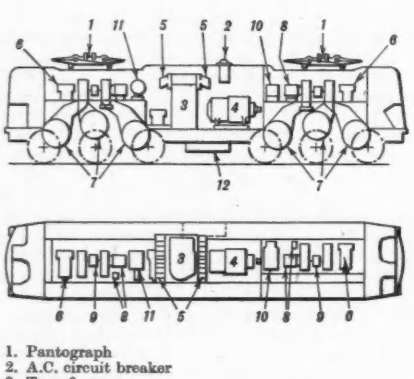
(*b*) The short vacuum gauge. This was identical in principle with the modern kenotometer, but the construction was slightly different, the U-tube being contained in a glass cylinder, which was connected to the condenser. The gauge read the abolute pressure in the condenser directly, but only gave a reading at the higher vacua.

(*c*) A slightly improved form of (*b*).

(To be continued)

Single Phase, 50 cycles-per-second Locomotive for the French Railways

FOR many years the French Railways, in common with other railway systems, have been trying to devise a practical method of realising the benefits inherent in the use of alternating current at 50 c/s for railway electrification. There are two main advantages of using high-voltage alternating current at normal power frequency. The first is the reduction or, perhaps, elimination of transformer and rectifier substations and the associated feeders which, in the case of d.c. systems are required every few miles along the track. The second advantage is that the reduction in line current makes it possible to use lighter overhead equipment and pylons, &c. It is estimated by the French Railways that the resultant saving in materials, manpower, structural work, &c., represents a reduction of as much as 55 per cent in the capital cost of electrification, as compared with the 1500V d.c. system at present standardised in France.



1. Pantograph
2. A.C. circuit breaker
3. Transformer
4. Motor converter
5. Main contactors
6. Reversers
7. Traction motors
8. Regenerative braking equipment
9. Motor blower
10. Motor compressor
11. Phase converter for supply to auxiliary machines
13. Battery

FIG. 1—ARRANGEMENT OF 50C/S LOCOMOTIVE NO CC-6051

Successful electrification schemes involving the use of high voltage alternating current at 16⅔ cycles per second have been carried out in other countries. But the use of high voltage at the standard frequency of 50 cycles per second has the added advantage that power can be taken without any special transformation from the national electricity supply system. Until recently the main objection to the general use of 50 c/s, high-voltage alternating current was the difficulty experienced in designing a suitable driving motor for the locomotive. It is claimed by the French Railways that the problem has been solved and three prototype locomotives have accordingly been ordered for the purpose of conducting comparative trials on the railway line now being electrified at 20kV, 50 c/s between La Roche sur Foron and Aix-les-Bains, in the Savoy Alps. The first of the three locomotives, which is the subject of this article, has been delivered to the French Railways and has begun its trials on the electrified section between Aix-les-Bains and Annecy.

Locomotive No. CC-6051

The mechanical parts of locomotive CC-6051 were built by the Société S.L.M., of Winterthur and the electrical equipment by the Ateliers de Construction Oerlikon, to the requirements of the French Railways. It is powered by six series-wound, single-phase traction motors, the design and construction of which constituted the main technical achievement of this project. The motors are supplied with a variable voltage (0 to 275V) by means of an oil-cooled transformer rated at about 3000kVA, which has a 20kV primary winding and a secondary equipped with a number of tappings. By means of these tappings the locomotive can be operated at sixteen economical running speeds. Provision is made in the equipment for regenerative braking.

To facilitate shunting operations at stations which are frontier points between single-phase and 1500V, d.c. electrifications, the locomotive has equipment enabling it to run at reduced power on a 1500V, d.c. supply. For this purpose it carries a converter set consisting of a 1500V, d.c. motor coupled to a single-phase alternator.

The auxiliary machines are driven by three-phase motors with an input of 380V derived from a single-phase to three-phase converter. A supply for train heating is taken either from a 1350V tapping on the transformer during single-phase working or at line voltage in d.c. operation.

Diagrams showing the general arrangement of the locomotive are given in Fig. 1 and the main dimensions, weights and performance figures are tabulated herewith.

Locomotive CC6051 for 20kV, 50 c/s, Single-Phase Operation.

Length over buffers	56ft 7in
Total wheelbase	43ft 3in
Bogie wheelbase	13ft 9in
Distance between bogie pivots	29ft 6in
Weights :	
Mechanical parts	60·56 tonnes
Electrical equipment	43·24 tonnes
Sand, tools and other appliances	0·70 tonnes
Total weight in working order	104·50 tonnes
Axle loading	17·40 tonnes
Outputs at 20kV, 50 c/s :	
Continuous rating :	
Horsepower at wheel treads	3990 h.p.
Corresponding tractive effort at wheel treads	36,000 lb
Developed at	42 m.p.h.
One-hour rating :	
Horsepower at wheel treads	4147 h.p.
Corresponding tractive effort at wheel treads	39,150 lb
Developed at	40 m.p.h.

Guaranteed Performance

To start and haul a train of 530 tonnes up 1 in 50 at 37 m.p.h.
To start and haul a train of 630 tonnes up 1 in 66 at 37 m.p.h.
To start and haul a train of 780 tonnes up 1 in 100 at 40 m.p.h.

Mechanical Construction

The locomotive body is carried on two three-axle motor bogies, the whole weight being utilised for adhesion. Each axle is driven by a fully spring-borne motor carried on the bogie frames, the transmission being by means of one set of single-reduction gearing per axle operating through a "S.L.M." flexible drive with floating ring. A general view of the locomotive is reproduced in Fig. 2, and the arrangement of the motors in the bogies is shown in Fig. 3. Fabricated construction is used for the bogie frames.

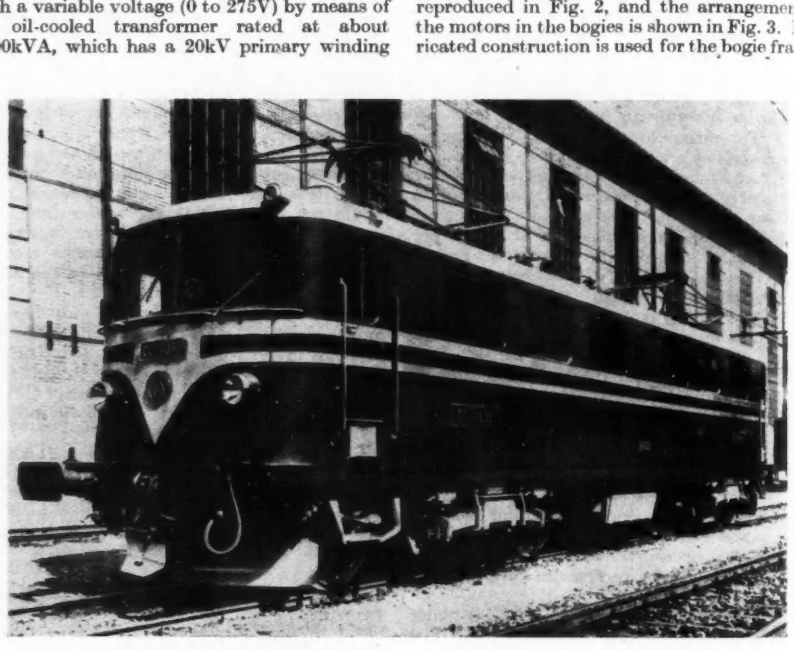


FIG. 2—LOCOMOTIVE NO CC-6051

The primary suspension consists of two square-section coil springs per wheel, associated with frictional damping devices.

The locomotive body is supported on each bogie by two resilient side bearers which form the secondary suspension and consist of double laminated springs attached to the bogie frame by links. A useful amount of damping for rotational movements of the bogies is provided by the friction inherent in the side bearers. To avoid the effect of weight transfer from the leading axles, each bogie transmits the tractive effort to the underframe through two links with spherical seatings which carry no vertical loading. The two bogies are interconnected by an arrangement which reduces the angle of attack on curves and reduces wear on the flanges of the guiding wheels; it takes the form of a linkage under compression between two triangular extensions attached to the inner ends of the bogie frames. The

"Athermos" axleboxes are attached to the bogie frames by links pivoting on Silentblocs. Together with the underframe, the body constitutes a single unit of all-steel construction,

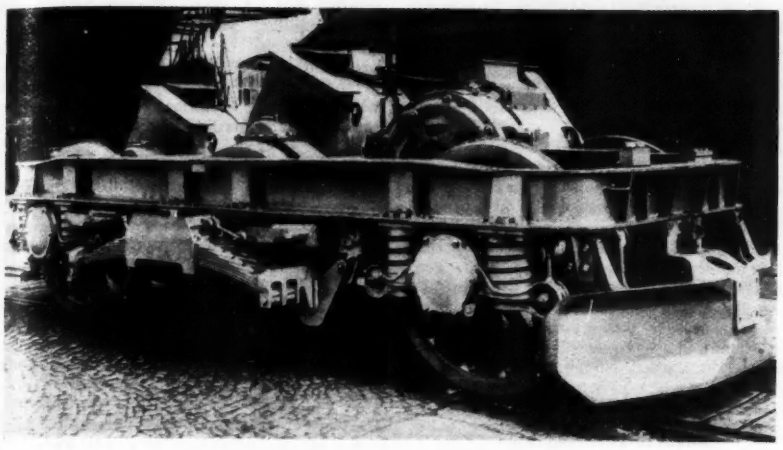


FIG. 3—ARRANGEMENT OF MOTORS IN BOGIE

built up of welded sections and sheets. The buffing and drawgear are carried on the ends of the underframe. The driving cabs, at each end of the body, have double walls to provide added comfort for the crew. As indicated in Fig. 1, the central portion of the body between

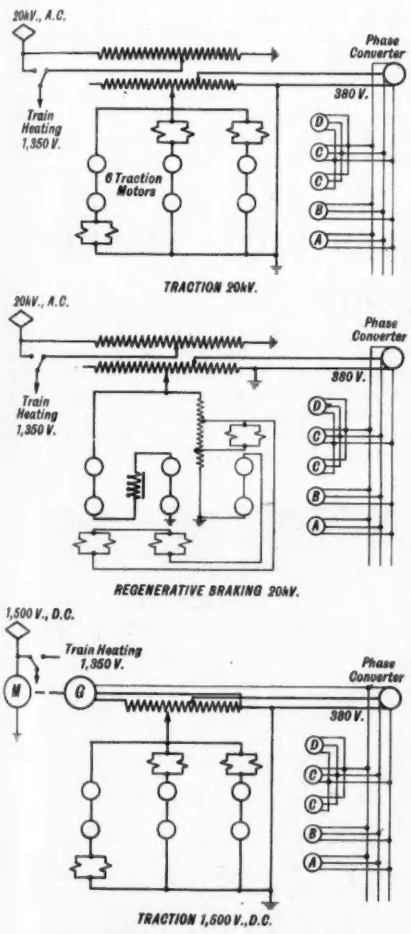


FIG. 4—BASIC CIRCUIT DIAGRAM

the driving cabs contains the electrical equipment and the auxiliary machines. A side corridor provides communication between the driving cabs, both of which have an entrance door on each side, opening inwards and provided with a sash window.

The brake equipment includes an automatic air brake for the train with two control positions, driver's equalising valves and triple valves, working in conjunction with a direct acting brake on the locomotive and a hand brake. The latter can be applied from each cab on the three axles of the adjacent bogie. In each bogie the brake gear is operated by two cylinders mounted on each side of the transversal main operating rod. Two brake blocks act on each wheel. An adjustment for the brake rigging permits compensation to be made for play in the action until the blocks are completely worn. Air supply for operating the brakes is provided by a single motor compressor set and is stored in the main brake cylinders at a pressure of 105 lb per square inch to maintain the main brake pipe at a pressure of 75 lb per square inch.

In addition, the locomotive has compressed-air sanding gear operated by pedals, whereby sand can be applied from either cab under the two leading axles of each bogie according to the direction of travel.

ELECTRICAL EQUIPMENT

As already indicated, the locomotive was designed primarily to operate on lines with a 20kV, 50 c/s, single-phase supply, but, for shunting purposes, it can also run at reduced power on 1500V d.c. supplies. It is powered, by six single-phase a.c. traction motors, the electrical connections being shown in simplified form in Fig. 4. When operating on 20kV, 50 c/s, as in the upper diagram, the current collected by the two pantographs is fed to the primary of a single-phase, 20,000/575V transformer, the secondary of which is equipped with several tappings so that the voltage supplied to the traction motors can be varied.

On a 1500V, d.c. supply (as in the lower diagram) the current from the same pantographs goes to the motor of a motor-converter set, the output side of which consists of an alternator giving a single-phase output at 300V to 500V, with a frequency range between 30 c/s and 50 c/s. The alternator feeds the secondary of the transformer, which in these circumstances acts as an auto-transformer, and the traction motor supply is derived from it through tappings in the same way as when running on a single-phase contact line, although the power is now limited by the capacity of the converter set. A system of interlocks, operated by a device that checks the positions of the switchgear before permitting the change-over to be made, prevents the application of 1500V, d.c. to the transformer or of the 20kV, 50 c/s supply to the 1500V, d.c. equipment.

As indicated in the middle diagram, the locomotive is equipped for regenerative braking when running on a single-phase supply.

TRACTION MOTORS

The main problems in the design and construction of the traction motors were concerned with the difficulty of achieving good commutation at 50 c/s, and it is claimed that a satisfactory solution has been found. The six traction motors are connected in three parallel circuits of two motors in series. They are compensated, series-wound, 16-pole motors with resistive shunts across the interpoles to effect a phase displacement of the flux. Forced ventilation is provided, the air flow to each motor being 3178 cubic feet per minute. A photograph showing a stator and a rotor is reproduced in Fig. 5.

The motor characteristics given in the accompanying table are based on the results of tests in accordance with the requirements of the International Union of Railways.

	One-hour rating	Continuous rating
Horsepower	710 h.p. ...	680 h.p.
Voltage	250V ...	250V
Current	2780A ...	2640A
Speed	1060 r.p.m. ...	1110 r.p.m.
	(40 m.p.h.) ...	(42 m.p.h.)

Each motor, without gears, weighs 2 tons 18 cwt. The weight per horsepower is 9·5 lb at the continuous rating and 9·2 lb at the one-hour rating; the weight per unit torque is 2 lb. per foot-pound (continuous) and 1·8 lb per foot-pound (one hour).

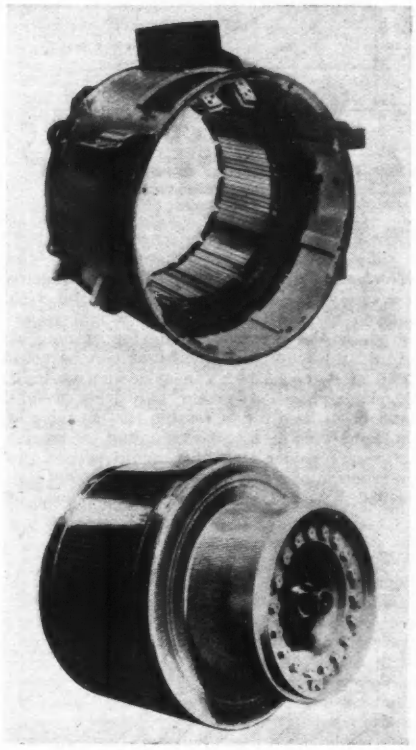


FIG. 5—STATOR AND ROTOR OF TRACTION MOTOR

The manufacturers have succeeded in achieving an output of 690 h.p. within the dimensions of a single motor capable of housing the bearings for the driven axle, and without exceeding the generally accepted constructional proportions.

The total number of notches is only sixteen, which is considerably less than would be required in a d.c. locomotive to restrict the changes in tractive effort, during notching, to the same level. This important advantage is due to the shape of the tractive effort/speed curves, which are favourably affected by the low saturation of the single-phase motors, the impedance of the transformer and the influence of the power factor.

The tractive effort/speed curves in Fig. 6 show the maximum outputs developed on 20kV, 50 c/s and on 1500V direct current. Train resistance curves of some typical trains, selected from the classes of traffic the locomotive will be called upon to work, are also shown on the diagram.

In Fig. 7 we reproduce the whole range of

tractive effort/speed curves on the various notches when working at 20kV, 50 c/s.

The motor converter, rated at 430kW (one hour) enables the locomotive to operate at reduced power in stations where the overhead supply is at 1500V, d.c., such as those on the boundaries between single-phase and d.c. electrification areas.

One of the objects of the prototype locomotives was to experiment with alternative d.c. operation. It is probable, however, that, if a fleet of single-phase locomotives were built,

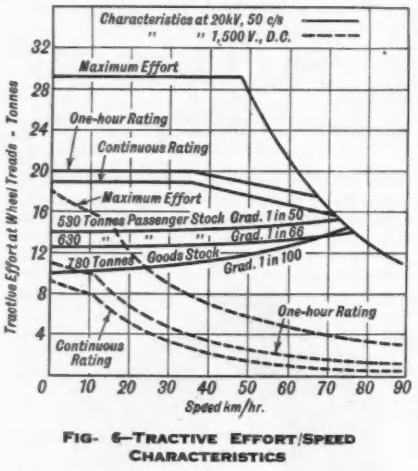

Characteristics at 20kV, 50 c/s
" " 1,500 V., D.C.
Maximum Effort
One-hour Rating
Continuous Rating
Maximum Effort
530 Tonnes Passenger Stock Grad. 1 in 50
630 " " " " Grad. 1 in 66
780 Tonnes Goods Stock Grad. 1 in 100
One-hour Rating
Continuous Rating
Tractive Effort at Wheel Treads - Tonnes
Speed km/hr.

FIG. 6—TRACTIVE EFFORT/SPEED CHARACTERISTICS

only a limited number would need this facility. It must be emphasised, therefore, that the performance of the new CC-6051 locomotive is severely prejudiced by the dual function required of it. The additional weight represented by the provision made for running at reduced power on direct current can be computed at 8 tons 5 cwt. In a locomotive built for single-phase operation only this weight could be utilised for increasing the capacity of the locomotive on a.c. working, and the manufacturers consider that this would permit the construction of a C_0-C_0 locomotive of 5920 h.p. (or 986 h.p. per axle), with a top speed of

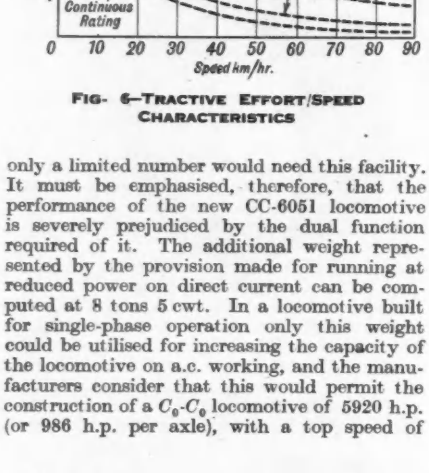


FIG. 7—TRACTIVE EFFORT/SPEED CURVES AT 20KV. 50C/S ON VARIOUS NOTCHES

77 m.p.h., weighing 115 tonnes. In the same way a B_0-B_0 machine for single-phase only could be built with a weight of 78 tonnes, rated at 3950 h.p., and a top speed, again, of 77 m.p.h.

AUXILIARY MACHINES

All the auxiliaries are driven by three-phase squirrel-cage motors supplied at 380V, 50 c/s, by an Arno rotary phase converter. This system gives the advantage of very robust machines which are lighter and much simpler in construction than d.c. motors.

Referring to Fig. 4, the auxiliaries comprise: first, a motor compressor *A* with an output of 87 cubic feet per minute at 120 lb per square inch; secondly, two motor blowers *C* for traction motor ventilation and cooling the oil in the transformer; thirdly, one motor blower *B* for cooling the resistive shunts across the traction motor interpoles; and fourthly, one motor-driven oil circulating pump *D*.

The train heating supply is taken either from a transformer tapping giving 1500V during single-phase operation, or from a connection on the equipment side of the 1500V circuit breaker during d.c. working. Current for control purposes and lighting is provided by a 72V battery (not shown in Fig. 4) on floating charge across a dynamo coupled to the Arno phase converter.

The other principal items of electrical equipment are two air-operated pantographs; one oil-immersed, 20kV circuit breaker; one main oil-cooled transformer rated at approximately 3000kVA; three reversers, which also act as the power-to-brake change-over switchgear; nineteen electro-pneumatic main contactors, sixteen for control of the traction motor voltage, and three serving as line contactors (one in each two-motor circuit).

In addition, the locomotive is equipped with single-phase d.c. change-over switchgear and a high-speed circuit breaker required for d.c. operation.

ELECTRICITY SUPPLY

At present the 20kV supply is taken from the Electricité de France 42kV network at Annecy. The substation consists of Scott-connected transformers, which step down the three-phase input at 42kV to two-phase at 20kV. Each of these 20kV phases is connected to one of the sections of the contact line, which is sectionalised by means of a neutral section at the substation. With this arrangement, when the loads on each section (Annecy to Aix and Annecy to La Roche-sur-Foron) are nearly equal, there is the minimum disturbance to the balance of the h.t. network. The substation equipment (one h.t. circuit breaker for protection of the Scott transformers and one circuit breaker in each 20kV output feeder) is controlled from a signalbox at Annecy station.

Since the supply will eventually be fed to the line at its two ends (at Aix-les-Bains and at La Roche-sur-Foron), the Annecy substation will only have to operate for three or four years. It has therefore been built and equipped on very simple lines. All the apparatus is outdoors (apart from a small hut housing the relays) and the h.t. lines are supported on wooden poles. Similarly, the connection with the Electricité de France network has been provided on a temporary basis by making use of the poles for the overhead telephone lines which gave way to underground cables when the branch was electrified.

EARLY TRIALS

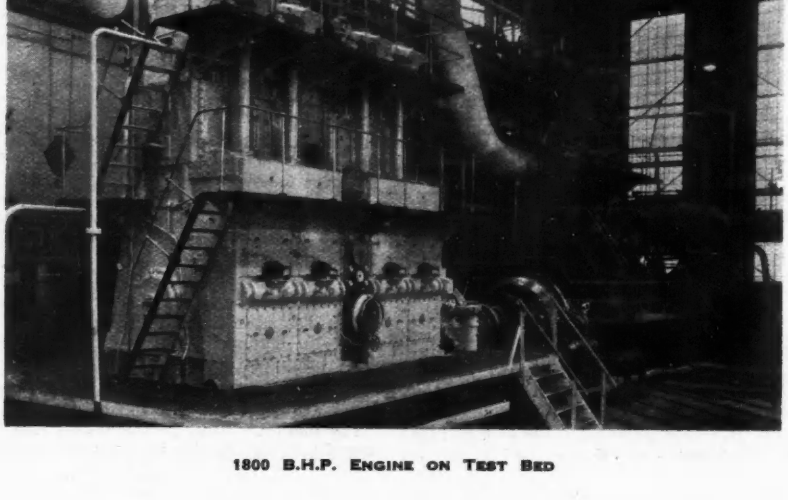
Last autumn, immediately after the delivery of the 20kV, 50 c/s, single-phase electric locomotive, CC-6051, trials began between Aix-les-Bains and Annecy, where electrification had been completed since June. Electric working on the section from Annecy to La Roche-sur-Foron will be possible in 1951, after completion of laying underground cables for the telephone lines.

We understand that the performance of the locomotive on trial runs has amply covered the requirements specified by the French Railways. The following examples indicate some of the tasks that have been satisfactorily carried out during the trials. One was a journey from Aix-les-Bains to Annecy (with gradients of 1 in 66), hauling a 640-tonne train of passenger stock with three intermediate stops, and a start on a 1 in 66 gradient. Another was a journey from Annecy to Aix-les-Bains (with one gradient of 1 in 125) hauling a 950-tonne train of passenger stock and making three intermediate stops. The commutation of the traction motors has been completely satisfactory.

The locomotive has now been taken into regular service and is running an average of 248 miles a day. Its performance, so far, justifies the confidence shown by the French Railways in their experimental work on electric traction with single-phase current at normal power frequency.

1800 b.h.p. Werkspoor-Lugt Marine Oil Engine

LAST week, at the works of Werkspoor, N.V., Amsterdam, demonstration trials were run with the new Werkspoor-Lugt 1800 b.h.p., four-cylinder, two-stroke, single-acting engine, for marine propulsion. The new unit, which is shown in the accompanying illustrations, will be installed in a cargo ship for the Oranje Line Maatschappij Zee-transport, of Rotterdam, which will be of 2800 tons deadweight carrying capacity and will shortly be launched from the De Merwede shipyard at Hardinxveld. When completed,



1800 B.H.P. ENGINE ON TEST BED

the ship will take her place in the owner's service from Rotterdam to Chicago, via Canada and the Great Lakes, and their connecting canals.

Historical Development

The engine was invented by the late Mr. G. J. Lugt, the Chief Engineer of the Diesel Engine Department of Werkspoor, N.V., during the occupation of the Netherlands by Germany. His intention was to create a new design which would follow and take the place, after the war, of the well-tried Werkspoor four-stroke engine, with under-piston supercharging. He sought to produce a unit engine which would be more economical, simpler, lighter and accessible; would have a high degree of reliability, would be cheaper to build, run and maintain, and would be able to use the heavier fuel oils.

For that purpose Mr. Lugt chose a two-stroke, single-acting design and embodied in it a simple scavenge pump for each cylinder, driven by levers from the crosshead. Straight-through scavenging was adopted with scavenge ports and four small exhaust valves in each cylinder head. The valves are arranged in two pairs around the central fuel valve, and their operating motion is taken from the reciprocating motion of the upper end of the scavenge pump piston by means of cams and rollers and a pull rod.

During the last years of the war, from 1943 to 1945, Mr. Lugt was able to complete the design of the prototype engine. A detailed account of that engine and the tests made with it were published in our issues of January 16 and 23, 1948. The test engine can be seen to the right of our main test-bed view.

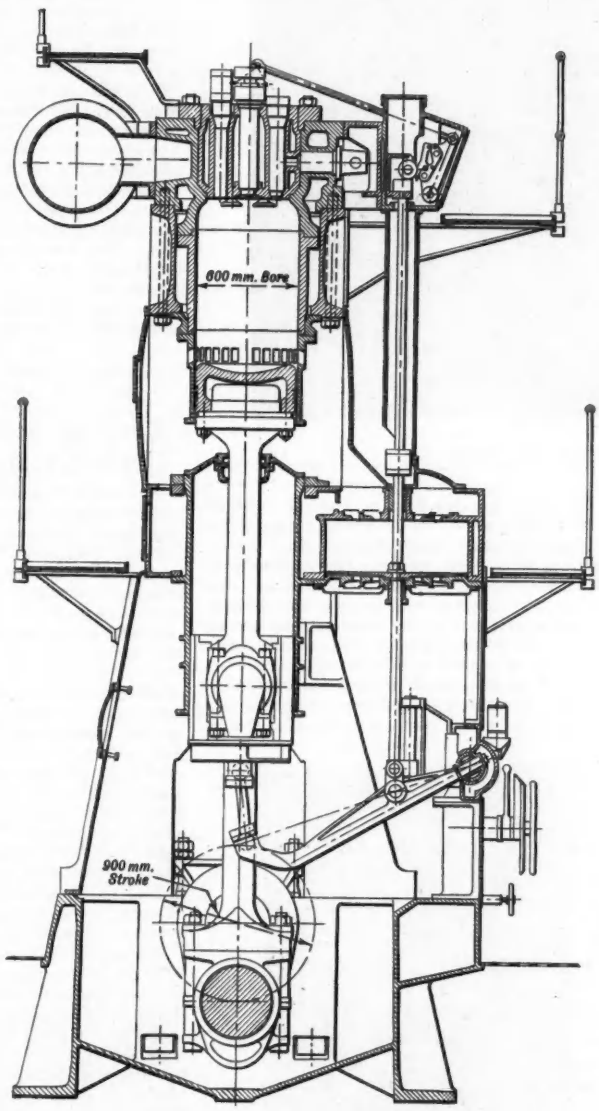
During 1948, Mr. Lugt was able to finish his work on scavenging and on the burning of heavy fuel oils and in that year he gave a paper on "The Scavenging of a Universal Diesel Engine" before the Association Technique Maritime et Aeronautique, in France. He had also arranged with the North-East Coast Institution of Engineers and Shipbuilders to give a paper on "More Diesel Varia," but his continued ill-health since the war led to his death in July, 1948. Some weeks before his death he was present at a two-weeks' continuous run of the test engine. To Mr. E. G. Asperen, Dip.-Ing., E.T.H., who was chosen as his successor, fell the task of reading the paper, which was followed by a full discussion, on March 29, 1949. An extract of the paper will be found in our issue of April 22, 1949.

On Mr. Asperen's return to Amsterdam it was decided to put in hand marine engines of the Werkspoor-Lugt design, in view of the interest shown in the engine, and possible orders.

The order for the Oranje Line engine was received on April 22, 1950, and the work of modifying the prototype design for commercial service was immediately put in hand and soon completed. On December 30, 1950, eight months after receiving the order, the engine was finished and it ran for the first time that day in the presence of many workers and staff.

Design and Construction

The illustrations and drawing, which accompany this article, show clearly the main points of design and construction. The bed-plate is of ribbed cast iron and it carries the main crankshaft bearings, which are of simple and robust design. The crankshaft is half built-up and is short and strong, the distance between the cylinder centres being 930mm or 1·55 times the cylinder diameter. The principal dimensions and particulars of the engine are tabulated herewith.



VERTICAL SECTION THROUGH ENGINE

When supercharged the engine power can be increased to 2400 b.h.p., about two extra tons being needed for the pipes and the exhaust gas turbine blower, which can be placed anywhere in the engine-room or, if necessary, outside it. For the present installation the engine is, however, unsupercharged. The lower cast iron columns, bolted to the top of the bed-plate, carry the scavenge pump beams, which also house the double-acting scavenge pump cylinder and the guide cylinders for the main cylinder crossheads. They are of equal diameter to the liner and are constructed so that they can be withdrawn through doors at the back of the engine. In the scavenging beams there is also the scavenging air receiver, which is continued upwards to the lower liner with the scavenging ports. The scavenge air receiver is closed at the front and back of the engine by detachable vertical covers, which facilitate inspection. A piston-rod stuffing-box separates the crankcase from the scavenging air receiver. The connecting-rods are drilled for forced-feed lubrication. Each of the steel crossheads is designed to form one piece with its piston rod and there are two crosshead guide shoes which run in a guide cylinder. They consist of two half-cylindrical shoes of cast steel, lined with white metal, and are arranged to permit adjustments being made to the diametral clearance in the guide cylinder.

The crosshead pin is completely ground and is cylindrical in form. It is fixed in the crosshead in such a way that its bottom part bears over the whole length of the white-metalled crosshead bearing. The crosshead also carries a ring on its bottom side, to which, by means of spherical articulated members, the links and levers for driving the scavenge air pump are connected. These levers and links have internal bores for the inlet and the outlet of the cooling oil for the main piston and guide shoes and for the lubrication of the crosshead bearings and the bottom end bearing, which is served with oil through the connecting-rod bore already mentioned.

Engine Particulars

Type of engine	K.E.S. 604/90 two-cycle, single-acting
Diameter of cylinders	600mm
Piston stroke	900mm
Output, unsupercharged	1,800 b.h.p.
Running speed	165 r.p.m.
Total weight	100 tons
Overall height, crankshaft centre to top	4,950mm
Depth, crankshaft centre to floor	1,000mm
Width of bed-plate at floor level	2,550mm
Total length over flywheel	6,550mm
Height required for transverse dismantling	5,370mm
Height required for centre line dismantling	6,200mm

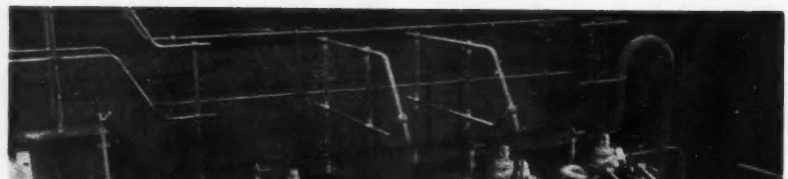
All the aforementioned moving parts and the guide cylinders for the crosshead are so arranged that they can be assembled and dismantled sideways. The same facility applies to the steel piston with its five rings and scraper ring, which can be withdrawn sideways without having to take away the piston rod.

For cooling the piston the oil passages in the central part of the piston are arranged as inclined nozzles, which impart a swirling motion to the cooling oil for the sides and crown of the piston. The arrangement gives a very cool piston and the temperature and condition of the cooling oil can be seen in windows at the front of the engine. The liner is in two parts, the upper portion, made in a special cast iron, being fastened to the cylinder head. As shown in our illustration, the two parts form one piece when assembled in the cylinder. The under-liner is formed in two halves, so that it permits easy dismantling for inspection and replacement if necessary of the piston rings. The cylinder covers are attached to the underside of the cylinder beam by heavy studs, which are screwed into the bottom of the cylinder head and are secured by nuts on the bottom side of the beam. Long through-going steel bolts are fitted to hold all parts together from the bed-plate to the cylinder beam and so to take up the combustion forces.

The cylinder head contains a central fuel valve and four simultaneously operated exhaust valves. In front of the fuel valve is the air starting valve and behind it the safety valve and the decompression valve for manœuvring.

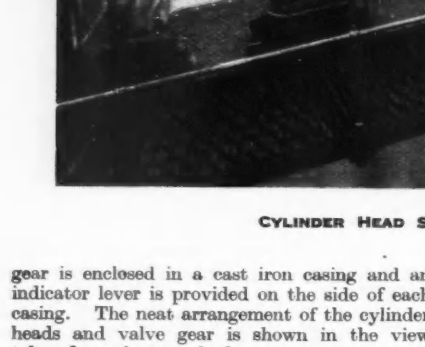
As will be seen from the drawing, the scavenging air piston rod is extended upwards and is used for the exhaust valve gear drive by means of cams and rollers and pull rods, each rod operating a pair of exhaust valves. There is no need for a camshaft. We found the working of this gear to be very smooth and practically silent, not unlike the valve gear of a modern horizontal steam engine. Fresh water is used

for cooling the main cylinders, the cylinder head and the injection valves, and tell-tale fittings on both the inlet and outlet valves show whether flow is taking place. The valve gear is enclosed in a cast iron casing and an indicator lever is provided on the side of each casing. The neat arrangement of the cylinder heads and valve gear is shown in the view taken from the top platform.



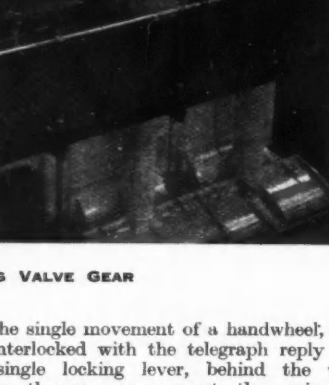
CYLINDER HEAD SHOWING VALVE GEAR

Interest attaches to the fuel pumps, which are placed between the two inner cylinders at the centre of the engine. The fuel cams are mounted on the crankshaft and they drive the four fuel pumps through rods arranged vertically within the crankcase, the pump unit being mounted at about half engine height. For reversing, the fuel pump plungers are turned from the ahead to the astern positions and by this movement the connections from the fuel pump to the fuel valves are interchanged.



CYLINDER ASSEMBLY

For starting air the pilot valves are arranged in one block in the centre of the engine beside the control panel. They are operated by a short camshaft, which is moved sideways to bring the ahead and astern cams into position. The engine controls are very simple. A view of the control panel is reproduced herewith. All manœuvring operations are combined in the single movement of a handwheel, which is interlocked with the telegraph reply lever. A single locking lever, behind the wheel, when thrown over, prevents the engine from being started in the wrong direction. By turning the control wheel from the central stop position the starting air camshaft is set to the required ahead or astern position and movement of the wheel in the same direction brings the starting valves into operation. Once the engine is running on starting air the further movement of the wheel automatically brings the fuel pump into action, while the final position adjusts the quantity of fuel for the desired speed.



CONTROL PANEL

During the demonstration trials the engine was run at full speed and half speed and, with an empty brake, twenty or thirty continuous reversals were made from ahead to astern. We noted that manœuvring from full ahead to full astern took less than four seconds. In every case the engine picked up and ran at about 50 r.p.m. and then increased speed with the movement of the wheel; slow running at 35 r.p.m. was also demonstrated. A neat arrangement of the Aspinall type of inertia governor is installed at the flywheel end of the engine, allowance being made for adjusting the speed at which the governor cuts out. At the back of the engine there are well-designed safety doors, which automatically release any crankcase pressure by means of a simple bell-crank lever and inclined spring, housed below the door. The thrust block is integral with the crankshaft and there is a turning gear on the flywheel.

The engine is designed to use boiler fuel of a viscosity of 3500 seconds Redwood, at 100 deg. Fah. For dealing with this fuel there will be two De Laval separators, one acting as a purifier and the other as a clarifier. To supply power for the auxiliaries two small Werkspoor 550 r.p.m. diesel engines with compressors for starting air and 220V, 8kW dynamos will be installed. During the demonstration trials ordinary diesel oil was used and we noted that the exhaust at all loads was invisible. The engine has a fuel consumption of 160 grammes or 0·355 lb per b.h.p.-hr at full load. The specific lubricating oil consumption for the cylinders, which are lubricated at three points by Bosch oilers, is about 3½ gallons per 24 hours. The operating results of this new engine will be awaited with interest.

Pumped Storage at the Etzel Power Station, Switzerland

A RECENT example of a hydro-electric scheme embodying pumped storage is that of the Etzel power station in Switzerland. There are two pumps installed in this station with an input of about 22,000 h.p., each at discharges of about 100 cubic feet per second and a head of 1575ft. From very early times repeated attempts have been made to regulate the discharge of large centrifugal pumps in the same way as that of Francis turbines. Although the investigations have produced interesting designs of guide equipment with special blade forms, no satisfactory solution has yet been found. Apart from the danger of vibration of the guide vanes, which may easily lead to flutter, this method permits a reduction of only 5 per cent of the total discharge quantity. The feeble effect of this guide-blade regulation in centrifugal pumps has an explanation in that the flow is influenced in the guide wheel only after the conversion of energy, while in the turbines this influence is exercised before the energy conversion.

To permit utilisation of even quite small supplies of surplus electricity the discharge of the Etzel pumps is regulated within wide limits by returning part of the total delivery quantity to the turbine. The storage pump thus delivers the whole water quantity and requires the full input. Since the driving motor obviously cannot give up more power to the pump shaft than is supplied to it in the form of surplus energy from the base-load stations, the rest of the power required to make up the full pump input is taken from the turbine of the storage pump set. The pressure energy required by the turbine for this purpose is furnished by the pump itself, part of the pressure energy it produces (or in other words, the corresponding quantity of water) being branched off to the turbine. The turbine, in its turn, gives up the kinetic energy it produces to the pump. This coupling of pump and turbine for partial-load service is said to be easy to put into effect, and to have given good results at the Etzel power station.

The problem of pressure fluctuations occurring as a result of the unintentional stopping of pumps and their subsequent rapid drop in speed—a problem which is, of course, encountered in very many pumping plants—presented itself in a serious form at the Etzel power station. If pressure fluctuations are caused in turbine operation by intentional regulating actions, they can be controlled with relative ease by the correct adaptation of the regulat-

ing members. In pump operation, on the other hand, such fluctuations are the result of sudden and unexpected operating troubles. The most common contingency is the rapid drop in pump speed, which follows the failure of the electricity supply and which has to be slowed down to reduce the wave of low pressure propagated outwards from the pump. Where the pumps are of high capacity very heavy centrifugal masses are required for this purpose. In such large pumping sets, on the other hand, operation in reverse has to be avoided at all costs.

In the Etzel station the storage pumps were coupled to existing generator sets, in which no measures had been taken to permit control of pressure fluctuations in pump service. Otherwise it would have been a simple matter to apply one of the usual systems and to fit the necessary shut-off members. In such cases it is usual to control the closing movement after the interruption of the electricity supply, in accordance with a system, which ensures that the shut-off member is still sufficiently open to allow the reflected pressure wave to pass as it returns, but closes completely before the pump comes to a standstill.

With the pumps at Etzel, however, the turbine is called upon to help in dealing with the pressure fluctuations. It is allowed to turn with the pump during operation of the latter and is always ready for service, as the sluice valves of the two supply pipes are open and only the turbine nozzles are closed by the pressure acting on them. The operation of the whole set is controlled, even during accumulation service, by the turbine governor. This governor was therefore fitted with the necessary protective devices, which, as soon as an interruption in the electricity supply occurs, at once open the turbine nozzles to an extent approximately corresponding to no-load operation of the set with the pump coupled up. In this way a rapid drop in the speed of the pump is prevented and the low-pressure wave caused is not strong enough to be dangerous. Disconnecting tests carried out after the starting-up of the storage pump sets—of which one is fed from a railway mains and the other from an industrial mains—were employed to examine the suitability of this arrangement.

The pumping plant at the Etzel power station was built and erected by the firms of Sulzer Brothers Ltd., and Escher Wyss Engineering Works Ltd. The latter company, which had previously provided the turbines and governors, studied and supplied the sluice valves, piping, couplings, the control gear mentioned above, and other parts of installation, while Sulzer Brothers built and installed the hydraulic energy storage pumps.

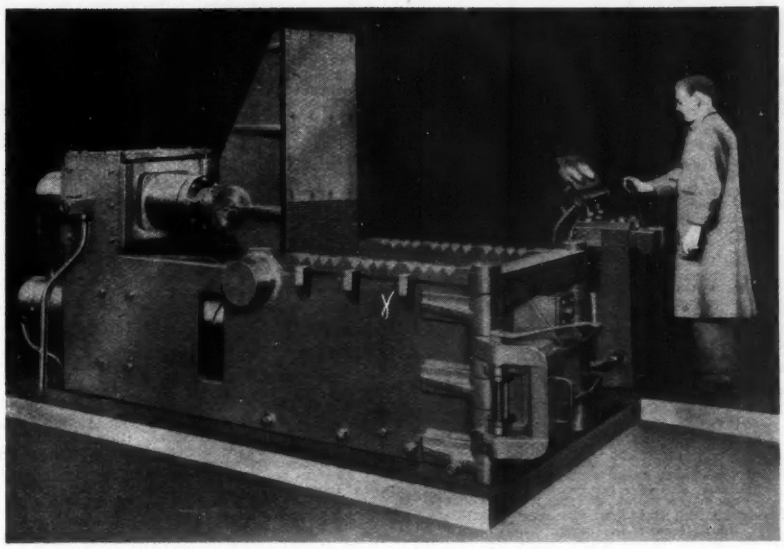
A Scrap Metal Baling Press

At the present time, when many raw materials are scarce, scrap metal baling machines are being used to an ever increasing extent in the engineering industry. This type of machine, in reducing unwieldy scrap material to bales of a convenient size and weight for economic handling and transport, makes it possible to return to the furnaces for resmelting much valuable metal, which would not only often otherwise be wasted, but is also difficult and expensive to dispose of.

For a number of years, Fielding and Platt, Ltd., of Atlas Works, Gloucester, has specialised in the design and manufacture of hydraulic scrap metal baling presses of the single, double and treble action types, and for producing bales weighing from ½ cwt up to 1 ton.

A recent useful addition to the machines made by the company is a self-contained, single-compression press for producing bales from 1 cwt to 2 cwt in weight, and which are 16in high, 24in wide and 6in to 8in thick, depending upon the loading of the box. This press has a box 49in long by 24in square, which, when it is closed, is 16in deep. In use, excluding the time taken to load and unload the box, the working time cycle of the press is 75 seconds, and it is designed to make 48 cycles per hour.

The press, which can be seen in the photograph we reproduce on this page, is of fabricated mild steel plate construction, the plates being securely tied together to give complete rigidity during operation. Special steel wearing plates are fitted round the inner walls of the box. Serrated shearing members are fitted along the sides at the top edges of the box in such a way that the lid, as it closes, cuts off projecting ends of scrap which would otherwise bend over and jam the lid. These shearing members, which are renewable, have cutting edges formed along both sides and can be reversed when one edge has become blunt.



HYDRAULIC BALING PRESS

Hydraulic power for operating the press is provided by a "Fielding" high-speed variable delivery radial pump driven by a 12·5 h.p. continuously rated squirrel-cage motor. The pump delivers oil at a pressure of 2 tons per square inch. All operations of the press are controlled through two levers on a remote control pedestal. These levers operate piston valves through which are controlled double-acting hydraulic cylinders used to close the lid and operate the baling ram of the machine.

In the cycle of operations the end door of the box is closed and locked before it is filled to capacity with scrap metal. Initial compression of the material is effected when the hinged cover is swung down on the box. The cover is actuated by a double-acting hydraulic cylinder and ram contained in a fulcrum crosshead, and when it is fully down it engages and locks on a spring-loaded catch on the end door. This catch prevents any tendency the cover may have to upward movement during the final compression stroke. It should be noted that scrap material too large to go into the box can be placed across the serrated members at the top of the box and sheared to convenient sizes by downward strokes of the cover. This operation can be repeated any number of times provided that the operator of the machine ensures that the cover does not complete its full stroke to engage with the end door locking catch. The cover exerts a preliminary packing load of 4–5 tons per square foot over the top of the scrap.

Final compression of the scrap in the box is effected by a second double-acting cylinder and ram mounted horizontally within the main frame of the press. The ram-head, which is forced lengthways along the box, is fitted with a special steel wearing plate. The ram has a working stroke of 49in, and it imparts a pressure of 30 tons per square foot on the material.

When at the end of the compression stroke, the pressure is released on the baling ram, the end door is unlocked and opened. The baling ram is again operated and, on moving forwards, ejects the bale from the end of the box. The end door is pushed to the fully open position during the ejection stroke and the cover catch is disengaged so that the cover can be swung up ready for the next cycle of operations.

The whole baling unit has been specially designed for ease in installation and maintenance and it can be effectively operated by unskilled labour after a short period of instruction.

Submarine Navigation

A paper on "Submarine Navigation" was read by Lieutenant-Commander P. G. Satow, R.N., at the Royal Geographical Society on Friday, January 19, 1950, and we summarise the main points below.

Last year the U.S.S. "Pickerel" completed a 5200-mile submerged passage across the Pacific in 505 hours, and it is noteworthy that throughout the passage the radio navigational receivers, radar and periscope (used for astronomical observations) depended entirely on above-surface information for fixing. These standard aids can no longer be used when the submarine has dived deep and the problems become entirely different. Soundings and an accurate knowledge of bottom contours and obstructions assume a special significance. Navigation in such circumstances becomes very largely a call upon the navigator's accuracy in estimating the effects of currents, tidal streams, eddies and turbulence on his dead reckoning. In most areas of the world, wind-driven currents predominate and their velocity decreases with increase of depth below the surface. When these currents meet a steep shelf or coastal region changes are affected in course and speed. In shallower depths tidal streams have complex changes in rates of flow, depending on the total depth. Theoretically changes in the direction of streams occur in depth but actual measurements from the surface in the open sea are difficult.

In 1948 H.M. Submarine "Talent" carried out a survey of the gravitational fields of the English Channel, using every available aid, including Decca, whilst on the surface, and streaming a taut wire from a sinker on the bottom whilst submerged. This enabled changes in the underwater streams to be followed and measured with considerable accuracy.

Apart from echo-sounding and the greatly restricted ASDIC there is little in the way of a navigational aid to offer the navigator who is confined to working below the surface. Recent research on an electromagnetic system of drift measurement by the Woods Hole Oceanographic Institute in the United States is therefore of special interest; the more so as it is dependent upon one of the oldest known aids to navigation, the natural magnetic field of the Earth.

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DEFENCE EXPENDITURE

LAST August, when the Government first made announcements about increased expenditure upon defence, it was possible, without seeming too sanguine, to suppose that the bulk of production for defence could be carried by industry without an overall reduction in the flow of goods to the home market or to exports, although not without the appearance of some shortages in particular classes of goods. For, after allowing for the period of delay inevitable before defence orders could reach the production stage, it seemed probable that an increase in national output, continued at the rate then ruling of about 8 or 9 per cent per year and concentrated very largely in just those engineering industries most likely to be affected by defence orders, would approximately equate to the extra production needed for defence purposes. It was, of course, even then obvious that taxation must be increased to carry the defence expenditure, unless, indeed, the Government could find means of economising elsewhere. But, in general, it seemed improbable that the standard of living in this country would be adversely affected and possible that, after some check during the first twelve months, it might resume its trend towards improvement. Indeed, in deciding upon an expenditure of £3400 million in a three-year programme the Government no doubt calculated that it was the most the country could bear without risk of adverse consequences for the existing standard of living or of failure to balance the oversea budget.

But Tuesday's announcement by Mr. Attlee in the House of Commons makes it no longer possible to suppose that the people of this country will be little affected by the additional expenditure upon defence. The total sum to be expended on the three-year programme has been raised to £4700 million. Even in the year 1951/52, the first of the programme, as much as £1300 million is to be spent, exclusive of any sums devoted to the building up of stocks of strategic materials, the latter in itself necessarily a costly process when prices of foods and raw materials are being driven upwards by the competing demands of many nations, all bent upon the same purpose. The total sum to be expended upon defence has now been raised far too high for it to be supposed that it can be simply absorbed by a natural increase in national output. Moreover, new factors have appeared since last September that make it dubious whether the high rate of increase in the national output that has been maintained over the last few years can continue much longer. Raw materials are not only costly to buy. The supply of them is proving insufficient to meet world demand; and even if the nations that are competing for them can reach agreement upon a "share-out," only the price will be affected. The amount available may still fall short of needs. Further, there is the equally direct effect upon production of the Government's "call-up" proposals. It is true that G and Z Reservists will be absent from work for only fifteen days. But there are some 250,000 men affected, so that the total loss of working days amounts to the not inconsiderable figure of close upon three million. Some of those men, too, no doubt occupy positions of some responsibility in industry, so that their absence may have a greater effect upon output than the mere figure of working hours lost would indicate. Of even greater importance, the scale of defence production now envisaged—it is to be doubled in 1951/2 as compared with the current year, and by 1953/4 should be more than four times as great—makes it certain that there will be interference with present production for civilian purposes, as existing shops are turned over to and re-equipped for the manufacture of military articles. There are to be combat vehicles of new design, notable improvements in the supply of new types of anti-tank and anti-aircraft weapons, and the programme includes the building and conversion of ships to deal with submarine and mining threats. As the engineering industry knows full well, there are many other stores and equipment that the Services will need in profusion. Not all this material, not even probably a substantial part of it, can be manufactured in the new factories that it is planned to erect and equip. There must, in fact, inevitably be interference with the existing and planned production schedules of civilian industry and rates of production are in consequence likely to suffer. It will be a pleasant surprise if we learn a year hence that national output in 1951 was appreciably higher than in 1950, although in subsequent years it may increase more rapidly than ever.

It is much too soon, as we go to press, to assess in full what must be the effects of this defence programme on industry within this country. Mr. Churchill and Mr. Clement Davies, in asking for a two-day or three-day debate on the matter, were wise to suggest that time for thought should be allowed before that debate takes place. Yet there is one point to which reference may be made at once. We must have these new armaments. We must, too, in a world in which raw materials have become costly, maintain the present level of our export trade if Britain is to pay its way. In seeking to abate the sacrifices that the people of this country will thus be called upon to make, the Government may therefore be tempted unduly to tamper with the rate of expenditure upon certain kinds of capital development within this country as a means of making more consumer goods available. It is, we think, temptation to be resisted. Under wartime conditions, when it can be foreseen that the war must be won or lost within a very few years, it is judicious to reduce expenditure on products that can have no influence on the outcome of the war. Labour can profitably be transferred from the manufacture of power station plant, railway equipment and maintenance, the building of bridges, the construction of docks, &c., to the making of immediately useful warlike apparatus. But those conditions do not rule when only the threat of war exists. Then it is a contribution to future warlike ability, to increase the potential productive capacity of the country by expending effort on the making of capital equipment. For, providing that sufficient force is in being to withstand the first shock of the war, it is the country which has at that time the greater productive capacity that is likely in the end to prove victorious. The fact that, in instructing firms to consult the Supply Department concerned when in doubt whether to give preference to a defence or to some other order, Mr. Attlee specifically mentioned generating plant in the latter class, makes it probable that the point is fully appreciated.

SKILLED MEN IN INDUSTRY

SINCE the war there has been a growing appreciation in this country that there is not only an existing shortage of craftsmen in industry but, even more seriously, a shortage of youngsters entering industry with the ambition of becoming craftsmen. That subject was discussed some months ago in our pages by Mr. Vincent Everard in one of our "Productivity in British Industry" articles. There Mr. Everard pointed out that though the "breaking down" of production operations and the development of

the single-purpose tool was reducing the need for skill in many production shops, yet unless there were adequate supplies of skilled men to make and maintain machines and tools, production must eventually suffer. At that time, in an editorial reference to Mr. Everard's contribution, we drew attention to the fact that the subject was to be discussed at the Institution of Mechanical Engineers when, on January 23rd, Mr. Loxham was to present a paper on "The Training of Craftsmen."

Unfortunately, the term craftsman is open to more than one interpretation. When Mr. Loxham read his paper, then, it turned out, as readers will have seen from the reprint that appeared in our last issue, that he chose to interpret craftsmanship in its broader sense, holding, with truth, that it is a quality just as essential to engineers and technicians as to men on the shop floor. His paper, therefore, discusses and describes a training scheme capable of producing professional engineers as well as people who will concentrate on the study of actual manufacture. Yet even within that latter group Mr. Loxham seemed to be thinking less of training the "skilled hand" than of improving the worth of a particular grade of technician, specialising upon workshop practice. Much of the discussion, therefore, turned upon the respective merits of differing schemes of apprentice training. In that it was undoubtedly valuable. For though such systems of training have long been under development they are still open to further improvement. But the paper and its discussion failed, unfortunately, to illuminate distinctly the point that had specifically attracted many of those present to the meeting. For the real trouble, as Mr. Wooding stressed in the discussion, is that "really intelligent boys will just not go into crafts." They want to be draughtsmen or technicians, not appreciating that just as much intelligence and at least as much imagination and integrity is needed for good craftsmanship as for those jobs. At present, in fact, it is the less intelligent apprentices, those who lack the ability to make much progress in National Certificate and other courses, who train for skilled work, rather than the more intelligent. In many places, therefore, the problem is not that of getting youngsters to enter for apprenticeship, but that of arousing an ambition amongst them to become skilled men rather than technicians. Elsewhere there is the additional difficulty of attracting youngsters to take an apprenticeship at all. For in certain areas a youngster about to enter industry learns upon inquiry that he can, at once, earn in an unskilled job in a high-production factory much more than he can command as an apprentice, with the prospect later of earning at least as much as he could as a skilled hand in a general engineering shop. The basic problem for industry, therefore, is not so much that of devising and improving methods of training skilled men, but of attracting young people of suitable intelligence to become skilled men.

The contribution of Mr. Wooding to the discussion was frankly depressing. He felt that in future industry "will have to make do with people of average and even below average intelligence and that more needs to be done about courses directed at that type." In saying so he was supporting Mr. Park, who earlier in the proceedings had viewed the problem as that of "the production of a large number of craftsmen covering a wide range of skills and ability from lads to whom the passing of the City and Guilds Intermediate Certificate would represent a very high standard of achievement." Such men, no doubt, could be trained to a degree of skill sufficient to meet more ordinary needs. But, as was repeatedly stressed at the meeting, really high standards of skill can only be reached by men of higher intelligence. How are such men to be obtained in sufficient numbers? That query suggests another question. Is there much attraction for an intelligent youngster to become skilled at present? According to Mr. Wooding, the older men in the works with which he is associated feel that it does not pay them to be more highly skilled than their fellows. For, on account of their skill, it is to them that are brought the more tricky and difficult jobs, those on which, if they are to be well done, there is little chance of earning much bonus! If, then, intelligent lads are to undertake several years' training to become highly skilled, life as a skilled man must be made more attractive than it seems to be at present, at least as attractive in prospect as that of a technician. If, for instance, by devising a suitable National Certificate course in craftsmanship a really high degree of skill could be guaranteed amongst those holding the certificate, employers might prove willing (were trades unions agreeable) to grant special rates of pay to them. Then the status of such men might be improved by granting them particular privileges such as freedom from "the clock" and contracts of service ensuring them against summary dismissal. No doubt many other suggestions could be made. We should like to see the subject discussed again by a major institution with the emphasis concentrated upon the present and prospective shortage of "skilled hands." For the discussion of Mr. Loxham's paper, good though it was, became diffuse through a lack of clear definition of the meaning of the word craftsman.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

THE DETERMINATION OF CRITICAL LOADS BY ENERGY METHODS

SIR,—Having read with interest Mr. M. D. Brisby's article on this subject in THE ENGINEER for January 19th, and as the author of an article covering the same subject (see *Civil Engineering and Public Works Review*, Volume 44, Nos. 516 and 517, June and July, 1949), I wish to record the following comments.

In the author's notation, $\Delta U - \Delta V$ is a particular type of variation of the total potential energy which assumes that a small displacement from the equilibrium position increases the internal energy of the system and decreases the potential energy of the (gravitational) system of loading. The presentation might have been more general had the total potential energy been formulated in full for the cases considered before employing the stationary potential energy principle.

Mr. Brisby's methods seem to depend upon assumption of the displaced form of the system. Such an approach is clearly only generally possible when the behaviour of the system is known beforehand. It is due to the stationary property of the critical loads (which is not verified in the article) for the cases considered, when certain assumptions are made, that they can be determined with good accuracy on the basis of approximate deformations which satisfy the boundary conditions.

In the more general and complex cases, the conditions for the total potential energy to be stationary, must be determined with the aid of the calculus of variations. A differential equation will result in each case (e.g., Euler's equation for the ideal strut), which can generally be solved by various approximate methods.

It is, in the writer's opinion, impossible to over-estimate the value of the stationary total potential energy principle, or more generally still, Lagrange's energy principle, for the study of the equilibrium of conservative systems.

T. M. CHARLTON

Stocksfield, January 25th.

MERGER OF INSTITUTIONS

SIR,—May I venture to suggest that the time has now arrived for the three major institutions to merge into one "Institution of Engineers"? Surely, not until such time that this, our profession, comes together as one will it take its proper place in society, a place which, for over a century, it has earned by the very nature of its work.

It would seem a highly unsatisfactory state of affairs to have a multiplicity of minor institutions, each with their own qualifications and standards, all of which only serve to confuse the public and lower the prestige and status of all. Surely their place could be taken by specialist divisions within the one institution?

ROBERT M. L. ELKAN, B.Sc.(Eng.)

Bournemouth, January 24th.

The Defence Programme

ON Monday last, January 29th, the Prime Minister, Mr. C. R. Attlee, made a statement in the House of Commons about the Government's defence programme. He prefaced it by saying that the Government did not believe that war was inevitable. The Government's purpose was to prevent war, but it believed that peace could not be ensured unless the defences of the free world were made sufficiently strong to deter aggression. It was for that purpose that the Government thought it right to take still further measures to increase the state of preparedness of the Armed Forces.

Dealing first with manpower, the Prime Minister said that the total strength of the Armed Forces would reach, by April 1st, 800,000 men, compared with the figure of 682,000 given in the last White Paper on Defence. We were, however, without the reserves of officers and men with up-to-date training who would be required to fill out the existing formations in an emergency. The Government therefore proposed to fill that gap by calling up a number of selected reservists who had the up-to-date training required, and giving them a period of refresher training. It had been decided to call up this summer, for fifteen days' training with the Army, up to 235,000 Reservists, officers and men. The great majority would be Class Z Reservists who were called up for service before the end of 1948. In addition, the Royal Air Force would recall for fifteen days' training about 10,000 officers and men who would be required to man the control and reporting organisation in emergency. The men would be drawn from the Class G Reservists, which was the equivalent of the Army Class Z. Legislation would be introduced in the near future to give effect to the proposals, and, by arrangement with the Ministry of Labour, no Class Z or G Reservist would be recalled who would be reserved for

industry in the event of a general mobilisation. The officers and men selected, the Prime Minister explained, would be those who, by virtue of their qualities and experience, could best fulfil the country's need at the time. He went on to say that the Royal Navy would call up about 6000 men from the Royal Fleet Reserve for eighteen months' service with the Regular Forces. The Navy would also need, for eighteen months, about 600 officers from the emergency list of the Royal Navy, the R.N.V.R. or the R.N.V.S.R. It was hoped that a good proportion of the Reservists concerned would be obtained by calling for volunteers. Then, too, the Prime Minister said, the Fighter Squadrons of the Royal Auxiliary Air Force were an essential part of the fighter defence of this country, and the officers and men of those squadrons, numbering about 2300, would be called up for three months' continuous training. The Royal Air Force would also recall for three months' refresher training about 1000 Air Crew Reservists, and about 200 Regular and Volunteer Reservists might be recalled for flying instruction duties for periods up to eighteen months. The general purpose of all those plans, the Prime Minister stated, was to make more effective the Regular Forces now in being, and to ensure that mobilisation, if it became necessary, could be carried out more rapidly and smoothly than would otherwise be possible.

The Prime Minister then spoke about production. He said that for the last five years the Forces had lived largely on their equipment stocks, and there was now urgent need of an increased production programme concentrated mainly on increasing their fighting strength. The completion of the programme in full and in time was dependent upon an adequate supply of materials, components and machine tools. In particular, plans for expanding capacity depended entirely upon the early provision of machine tools, many of which could only be obtained from abroad. If the plan was fully achieved, Mr. Attlee said, expenditure on production for the Services in 1951–52 would be more than double the rate for the current year, and by 1953–54 it should be more than four times as great. By then, the annual output of tanks and combat aircraft should have been quadrupled. New types of equipment would be introduced as rapidly as possible, new types of fighter aircraft would come into service in larger numbers, production of the twin-engined "Canberra" bomber would be increased, and the first order was being placed for a four-engined jet bomber. Combat vehicles of new design would be introduced, and there would be notable improvements in the supply of new types of anti-tank and anti-aircraft weapons and equipment. The programme for building and converting ships to deal with the submarine and mining threats would be greatly accelerated. After a reference to the Civil Defence programme, which, he said, was designed to deter aggression, the Prime Minister stated that, over the whole field of military and civil preparations for defence, apart from the stockpiling programme, expenditure in the financial year 1951–52 would be in the neighbourhood of £1,300,000,000. It would take time to build up defence production to the levels which the Government now had in mind, and expenditure on production would be on a rising curve during the next three years. If the programme was fully achieved, the total defence budget over the next three years, covering all the military and civil preparations, but again excluding stockpiling, might be as much as £4,700,000,000, nearly half of which would be for production.

Finally, the Prime Minister gave a broad indication of the economic implications of the programme. The Government's aim, he said, was to see that we carried as much of the load as possible ourselves, now, and refrained from mortgaging the future by running into debt abroad or reducing the investment on which our industrial efficiency depended. That, he acknowledged, would be a task of great difficulty because the industries which would have to carry most of the increased defence orders—the engineering and metal-using industries—were the very ones on which the country had relied to make the biggest contribution to exports and to industrial equipment. The task was to turn over progressively to defence production sections of the engineering industry, especially those producing aircraft, vehicles, radio and radar equipment, and machine tools. Some new factories would have to be built, and authority had already been given for two additional tank factories and for several new production lines for the most modern types of jet engine. But, Mr. Attlee emphasised, for the most part existing capacity must be relied upon, and much of the new work under the increased defence programme must replace work that was already going on. That would inevitably reduce the exports of those industries, particularly now when labour and materials were so scarce. The rest of industry, therefore, must be called upon in two ways. When the main contracts had been placed, those sections of the engineering industries which were now producing goods for current consumption would be called upon to take some of the strain of producing components and so forth under sub-contracts. Secondly, the Prime Minister observed, those and other industries, such as the textile industry, would have to expand their exports still further.

In that way, Mr. Attlee concluded, it was aimed to maintain a balance in our overseas accounts, at the expense primarily of home consumption, although some reduction in the supply of plant and machinery would be inevitable. There must also be some reduction in the civil building programme, though the utmost would be done to avoid large or widespread interference with it. If, as the programme developed, it appeared that exceptional measures were necessary to ensure the availability of labour, the Government would not hesitate to take them. The fulfilment of defence orders must be regarded as of special importance, and carried through with all possible urgency. Some firms, for their own protection, would have to be given directions about the volume of defence orders which they must accept, and the timing of them in relation to other orders. In other cases, where a firm was doubtful whether a defence order should have preference over other obviously important orders, such as equipment for a generating plant or an export of special importance, the firm should consult the Supply Department concerned which would arrange for the necessary guidance to be given. The programme, the Prime Minister remarked, would have far-reaching effects on the pattern of industry. To carry it through effectively and smoothly, The Government would need the fullest support and co-operation from managements and men. It was confident that such support would be forthcoming, and both sides of industry would be taken fully into consultation at every stage of the programme.

The Railway Executive

THE Minister of Transport announced on Tuesday last that Mr. John Elliot had accepted an invitation to become chairman of the Railway Executive, in succession to Sir Eustace Missenden, who has now retired from that office. Mr. Elliot has been Chief Regional Officer in the London Midland Region of British Railways since 1949. Prior to nationalisation he was on the staff of the Southern Railway, the public relations department of which he joined in 1925. He became traffic development officer of the Southern in 1930, assistant traffic manager in 1933, deputy general manager in 1937, and acting general manager in 1947. Upon nationalisation of the railways, Mr. Elliot was appointed Chief Regional Officer of the Southern Region in 1948, and transferred to the London Midland Region in the following year.

A LIMITED number of copies of the "Tabular Summary of Civil Engineering Contracts," which was published with last week's issue of THE ENGINEER, are available for sale at a price of 1s. 6d. per copy post free. Application should be made to the Manager, THE ENGINEER, 28, Essex Street, Strand, London, W.C.2.

Literature

Die Eigenschaften des Betons. By OTTO GRAF. Berlin: Springer. Price DM36.

ALTHOUGH concrete has been used as a building material for a very long time, it was not until the beginning of the present century that the properties of concrete began to be investigated and the results were utilised in structural design. Most of the early research dealt with the influence of water and the grading of aggregates on the strength and deformation characteristics of concrete. One of the pioneers of this work was Professor O. Graf, of Stuttgart University, whose important findings were described in his book, "Der Aufbau des Mörtels und des Betons," 1923, which found wide circulation. He and his assistants have since carried out much further research which is scattered in a large number of scientific and technical papers. It is therefore timely to collect this information under one cover, which has now been done. The present book contains a systematic treatment of the properties of concrete and the underlying investigations, mainly those undertaken in his own laboratory; some of his more recent work carried out just before and during the last war is published here for the first time.

The book begins with a summary of the properties of concrete materials, cement, aggregates and water, in relation to cement mortar and concrete whose composition is considered in some detail. The experimental results are arranged in numerous tables and graphs and illustrated by excellent photographs. Subsequently the strength and deformation characteristics of various mortars and concretes are given, followed by their physical properties and resistance to chemical attack and weathering. This section of the book contains a wealth of information not only for the research worker, but also for the concrete engineer; the numerous data are well presented in tabular and graphical form and many very good photographs, especially of concrete sections. The well-illustrated treatment of the proportioning, mixing, testing and placing of concrete is followed by a chapter on lightweight concrete, which is almost entirely based on the results of wartime research. The same applies to the short section on soil-cement concrete, which is to be followed by a more detailed treatment by the author in the future. The book ends with a chapter illustrating by means of examples the application of the previous sections in practice.

Although the experimental data presented by the author are mainly obtained from his own work, the results are frequently compared with those published by other universities and public laboratories. His review, although necessarily brief, of their research adds considerably to the interest of the book. The treatment is further enhanced by the many tables and illustrations throughout the book but, for reference purposes, it is hoped that an alphabetical index will be added at the end of future editions. The book is likely to be one of the more important post-war publications on the properties of concrete, and its authoritative contents should appeal to concrete engineers and scientists alike.

BOOKS RECEIVED

Mathematical Theory of Plasticity. By R. Hill. London: Oxford University Press, Amen House, Warwick Square, E.C.4. Price 35s.

Radio Laboratory Handbook. By M. G. Scroggie. London: Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 15s.

Hand Tools (For Wood and Metal Work). By R. Harries. London: G. Bell and Sons, Ltd., Publishers, York House, Portugal Street, W.C.2. Price 5s.

Thirty Years' Development of Opposed-Piston Propelling Machinery*

By W. H. PURDIE, M.I.MECH.E.

No. II—(*Continued from page 132, January 26th*)

Three-Cylinder Engine

In 1924 we made quite a number of important steps forward. We introduced the spherical combustion chamber, the three-cylinder engine and centrifugal purification of fuels on board ship.

The introduction of the three-cylinder engine was an attempt to produce a short, simple type of engine driving all its own auxiliaries at sea and of interest to the owners of tramp steamers of low power, whose previous vessels had been entirely triple-expansion, saturated-steam types with no refinements. No special problems were involved except that of starting the engine. When you have three cranks and the normal size of exhaust ports it is difficult to design the engine to be certain to move from any position unless you put the first pair of piston-rings near the firing edge of the pistons. Otherwise the starting air goes away. This engine was of cast iron construction. It was something like the "Yngaren's," but instead of having four columns for each cylinder there were only eight columns in all for three cylinders. We were able to get 1800 b.h.p., 85 to 90 r.p.m.

Balancing

The four-cylinder engines built up to that time had all been fitted with central crank-driven scavenge pumps, where there were suction valves in the upper and lower faces of the hollow box piston, the air entering through a suction trunk attached to the piston, and passing through the top cover. The pump bodies were made of cast iron and were quite heavy and there were no balance weights fitted to the crankwebs. The first engines were running at 72 to 75 r.p.m., and the frequency of the pulsating primary force due to the heavy piston was much lower than the frequency of the hull structure. We had no ill-effects. You can take great liberties with unbalanced forces in a ship if you are sure you are not going to have resonance or agreement between the natural frequency and the hull frequency. With the fourth and fifth vessels, however, we got up to 85 r.p.m. and landed into serious vertical trouble due to the big force. The remedy was to put balance or tail weights on the crankshafts and, since we were more worried at that time about the vertical than the horizontal vibration, we over-balanced so that we reduced the primary vertical force to zero but at the expense of introducing a horizontal primary force.

In 1925 we started on twin-screw work, the first ship being the "Port Dunedin," with engines of about 5000 indicated at 95 r.p.m. On that ship we had no trouble with vibration. But the troubles we had had with these early ships at 85 r.p.m. were getting known all over the country and were being talked about. In 1926, therefore, when two quadruple-screw passenger liners were out for tender and the Doxford engines were being seriously considered, the engineer advisers of the two shipbuilding firms who received the orders refused to take any responsibility for vibration if such engines were fitted, because we had serious unbalanced force from the working cylinders as well as from the scavenging. It could not be denied that these forces were there and, with our backs to the wall, we refused to be crowded out of the fast-running market and we evolved, in June, 1926, three months later, a balanced engine, by altering the upper and lower strokes of the engine. It is obvious, looking at the engine, that the reciprocating weight when there are two long connecting rods and two long side rods and a crossbeam for the upper piston must be greater than on the lower piston. We altered the strokes, which had been similar, to the ratio of 4 lower to 3 upper, and that brought the crankshaft gratuitously into almost complete running balance. This has remained our practice to the present day. It is interesting that this was the first case where the four-crank, four-cylinder, two-cycle, single-acting engine, with firing impulses at 90 deg. had been produced with complete primary and secondary balance.

The upshot was that in June, 1926, the M.V. "Bermuda," built by Workman Clark, had four four-cylinder Doxford engines, 600mm bore, 1800mm stroke, with a designed maximum aggregate power of 13,200 b.h.p. at 120 r.p.m.

Fuel Pump Bodies

In 1927–28 the number of vessels was increasing and we began to get into trouble with the short life obtained from fuel pump bodies. These bodies are subject to considerable pulsation of pressure when you have 6000 lb in the system and a pump with atmospheric pressure in the pump barrel. The pressure may run to 8000 lb or 9000 lb per square inch. The bodies of the fuel pump were made of 3 per cent nickel steel to get a hard seat for the suction valves. We went from 3 per cent nickel to nickel-chromium steel, oil toughened, and to nickel-chromium molybdenum steel, oil toughened. The higher the tensile strength the worse was the trouble and we came back to mild steel and superior fatigue value. We still use it.

Torsional Vibration

In 1928–29 we ran up against some severe torsional vibration trouble. On the four-cylinder engines we had a very heavy flywheel at the aft end. It was made to give a certain coefficient of fluctuation of speed. We did not make the elaborate calculations on torsion vibration which we make now. Unfortunately, owing to the crank sequence having been altered from 1, 3, 2, 4, to 1, 3, 4, 2, we got into difficulties. The cure was to take off the flywheel and substitute a lighter wheel, raising the two-node frequency and running at 98 r.p.m. between the ninth and tenth order. Later engines have two flywheels.

Five- and Six-Cylinder Engines

With the introduction of five-cylinder engines in 1935 and the study of torsional conditions the need for some form of vibration suppressor was apparent. In conjunction with Mr. James Bibby, the Doxford-Bibby detuning wheel has been evolved and very successfully applied by us and our licensees since the spring of 1935. All four-cylinder engines as well as all five-and six-cylinder engines, have this spring-driven gear at the forward end.

Constructional Changes

During the period of depression in the shipbuilding industry from 1931 well into 1934, one of the biggest changes in construction was introduced when the use of cast iron for bed-plates, columns and entablatures was abandoned and electrically welded steel plate construction was substituted. We got a slightly more compact design and the saving in weight was about 25 per cent in the average engine. The opposed-piston type of engine, in which the main combustion loads were carried entirely by the crankshaft and running gear, was ideal for fabricated construction because the framework had only to carry the dead weight of the running gear and the only stress on the columns was that due to torque reaction. The dimension of the pieces could be much larger than when cast in a foundry because of the limit of 20ft. We were welding up to about 30ft.

With these alterations we revised the design of the crankshaft. You will realise that there was no background of experience of this type of crankshaft and we were, naturally, careful. The journals by calculation do not carry any bending moment. The bending is only between the side of the crankpins and the centre, but you cannot have a shaft as a continuous girder and then put a lower stress on one section. It must deflect and if one part deflects the next section must deflect. The main bearings are of the spherical type and the shaft is a continuous girder. We therefore altered the journals to the same diameter as the crankpins and used every effort to get a uniform flexibility from end to end of the shaft. Anyone who has been accustomed to deflections between the crankwebs of the ordinary single-piston type engines may be astonished when he comes to an opposed-piston shaft. The deflections are enormous! On some of our long-stroke engines, built in 1926, the movement alone without firing and turning the engine round from top to bottom centre was nearly a sixteenth. But there is still in use a shaft that went to sea in 1926 and I think it will go for the life of the ship. We were criticised very much in the early days on far too flexible a shaft but I would rather see a flexible shaft and a rigid bed-plate than a rigid shaft and a flexible bed-plate.

On our early ships we drove the camshaft by spur and bevel gears and spiral gears. We have now adopted, for the past fifteen years, a roller-chain drive, which seems to be satisfactory. Our early guide shoes were of the circular torsion type but all are now of the slipper type, allowing a very small working clearance between shoe and slipper, and this gave more silent operation.

In fuel consumption we have progressed steadily. The "Pacific Trader," in 1924, used about 0·41 lb per b.h.p.-hour at 2900 b.h.p. and 87 r.p.m.; the three-cylinder "Tamele," of 1944, uses about 0·34 lb at 2972 b.h.p. at 112 r.p.m. These consumptions have been obtained with a good brand of gas oil of about 0·88 specific gravity and 19,300 B.Th.U. per lb (gross). We are down to about one-third lb per b.h.p.-hour, although we have not been able to repeat it on any other type of engine.

The highest powered and largest vessel so far placed in service is the "Dominion Monarch," built by Swan, Hunter and Wigham Richardson, of Wallsend-on-Tyne, for Messrs. Shaw, Savill and Albion, Ltd., in

* Institution of Mechanical Engineers. Twenty-third Thomas Lowe Gray Lecture. Extracts.

1939, for the Australia-New Zealand run. It is fitted with four five-cylinder engines of 725mm bore and 2250mm stroke.

Larger engines than any so far completed are under construction in Britain for a number of single-screw oil tankers. These have six cylinders, of 750mm bore and 2500mm combined stroke and develop about 8400 b.h.p. at 108 r.p.m. The weight of the engine is 525 tons and the crankshaft is 22in in diameter and weighs, with thrust shaft, 116 tons.

Standard British Mixed Traffic Locomotive No. 70,000

No. I

THE first standard locomotive for British Railways, a 4–6–2 mixed traffic engine for express passenger and fast freight services, was recently completed at Crewe works. This locomotive, No. 70,000, has been named "Britannia," and is one of twenty-five similar Class "7" engines which are to be built this year, together with 134 other standard locomotives for British Railways. The first fifteen locomotives of this class to be built at Crewe will be allocated to the Eastern Region, and the other ten will go to the Western Region. They are particularly intended for the main line passenger and fast freight services of the Regions "V 2" class, and the Southern Region "West Country" locomotives.

Prior to the naming ceremony of "Britannia," which took place at Marylebone Station on Tuesday last, the locomotive underwent running-in and preliminary trials in the Crewe area, and on the main line between Crewe and Carlisle. As in the case of the other standard classes which will enter service this year, the new locomotive has been designed under the direction of Mr. R. A. Riddles, member of the Railway Executive for mechanical and electrical engineering. Although the engine was built at Crewe, and Derby is the parent office for the design of this particular class of locomotive, it should be pointed out that important sections of it were designed at Brighton, Doncaster and Swindon as part of the Executive's policy of using the resources of all the regional mechanical drawing-offices to cover the standard types as a whole.

MIXED TRAFFIC LOCOMOTIVE "BRITANNIA"

Main Particulars of Locomotive No. 70,000.

Cylinders (two)	20in by 28in
Coupled wheels	6ft 2in dia.
Wheelbase, rigid	14ft
Total weight in working order (engine)	94 tons
Boiler pressure	250 lb per sq in
Heating surface:	
Tubes: 40 large, 5¼in O.D.	2,264 sq ft
136 small, 2⅛in O.D.	
Firebox	210 sq ft
Total evaporative	2,474 sq ft
Superheater	718 sq ft
Total	3,192 sq ft
Grate area	42 sq ft
Tractive effort	32,150 lb
Adhesion factor	4·23
Minimum radius curve (with specified gauge widening)	4½ chains
Tender:	
Coal capacity	7 tons
Water capacity	4250 gallons
Weight empty	21 tons 4 cwt
Weight full	47 tons 4 cwt

The leading particulars of the new locomotive, which will be described in some detail in the next issue of THE ENGINEER, every endeavour has been made to embody all the features calculated to increase mileage between repairs, give the maximum economy in operation, ease of access for servicing and repair, and a high degree of interchangeability of parts with other standard stock.

(To be continued)

THE BRITISH RUBBER DEVELOPMENT BOARD has opened an office at Charter House, 4, Bank Place, Melbourne, Australia, under the management of Mr. W. B. Hardeman.

Electrical Meteorological Instruments

A SYMPOSIUM of papers on electrical meteorological instruments was presented at a joint meeting of the Measurements and Radio Sections of the Institution of Electrical Engineers and the Royal Meteorological Society on January 30th. The meeting was in two sessions. In the afternoon session Mr. G. E. W. Hartley read his paper on "The Development of Electrical Anemometers," in which he discussed methods of calibration and standardisation in relation to the accuracy and speed of response of standard instruments. Reference was made to the cup anemometer which drives a generator, with an autographic recorder, consisting of a recording voltmeter for the wind speed and a wind vane connected by a self-synchronous a.c. transmission system to a recorder to register the wind direction. Such a combination was found to be of great general use in the Meteorological Office.

In the second paper, Mr. H. H. Rosenbrock and J. R. Tagg dealt with "Wind and Gust-Measuring Instruments Developed for a Wind Power Survey." Two recorders were described, the essential characteristics of both instruments being that they should operate unattended for a week. The first instrument was a photographic recorder which showed at half-hourly intervals the wind direction and run of wind past four standard cup-contact anemometers. The second instrument was designed to make a mark for each 2 miles per hour of wind, making up to four simultaneous records. In the gust-measuring anemometers a perforated aluminium sphere formed the detecting element, a mechano-electronic transducer valve being used to convert the mechanical response into an electrical output. Compensation for temperature changes and the static effects of atmospheric pressure was embodied in the instrument. When used with an amplifier-driven recording voltmeter the response of the prototype instrument to an instantaneous change of wind speed from 65 to 85 m.p.h. was completed in about 0·07 sec.

An "Electrical Method of Resolving True Wind Velocity Aboard Ship" was the subject of the next paper, which was presented by Mr. H. D. Hawkes and Mr. J. D. Lawes. The method described by the authors involved polar resolution by a.c. representation of force vectors. The paper gave an outline of the apparatus needed for primary measurement and resolution and the accuracy of the original

resolving gear under practical conditions was indicated.

To conclude the afternoon session, Mr. J. Bell and Mr. E. M. Langham read a paper on "Mean Wind Velocity Instruments for Use on Naval Craft." Two instruments made during the 1939–45 War were described. The first was fitted to auxiliary aircraft carriers and indicated the mean wind direction, so that the vessel could be steered correctly for the take-off and landing of aircraft. The second instrument was fitted on larger naval craft for meteorological purposes; its function was to indicate, in various positions in the ship, the direction and speed of the mean true wind and the mean apparent wind. In both instruments use was made of magslip transmission elements and electrical computing devices, which were developed for fire-control instruments and were later adopted for meteorological work.

Opening the evening session, Dr. F. E. Jones, Mr. J. E. N. Hooper and Mr. N. L. Alder read their paper on "The Radar-Sonde System for the Measurement of Upper Wind and Air Data," describing a new system of meteorological sounding, using secondary radar principles. In that system, pressure, temperature and humidity are each telemetered to an accuracy of one-thousandth part of their operating range, although the instrument elements in use might not be capable of measuring the meteorological parameters to that degree of accuracy. Wind speed and direction are automatically measured. The authors said that the maximum slant range of the system was about 100 miles; therefore, the height to which soundings and wind measurements could be made was, for the present, largely limited by the height at which the balloon carrying the instruments would burst.

The next paper, by Dr. A. W. Brewer and Mr. R. H. Dobson, was concerned with "An Automatic Frost Point Hygrometer for Measurements in the Upper Air." The authors showed how the automatic instrument was evolved naturally from the manually operated frost-point hygrometer and a frost-point hygrometer using photo-electric indication of the dew or hoar-frost deposit, both instruments having shown their value in meteorology. Both instruments, for example, could measure absolute humidities as low as 1mg/m³, corresponding to a frost point of −80 deg. Cent. To reduce the required observational skill, however, a fully automatic hygrometer was developed. In the paper the conditions to be satisfied by an automatic instrument were outlined and some of the special difficulties were discussed. A short description was given of an instrument which had complied with laboratory tests and would measure any frost point from room temperature down to −80 deg. Cent., below which operation became impossible owing to the slow rate of crystal growth at those low temperatures.

In the final paper, "Some Meteorological Instruments Used in Building Research," the authors, Messrs. A. W. Pratt, B. G. Collins, R. E. Lacy and E. W. Spink, described four electrically operated meteorological instruments, traced the reasons for their development, and gave examples of their use. The first instrument, a wind-run analyser, was used to record the run of wind over successive time intervals, varying from five minutes to one hour, as required. The second instrument was a wind-direction recorder designed to show, on meters, the run of wind during any period, from each of eight directions. The third instrument was an equivalent air temperature recorder, for measuring the equivalent temperature to which walls of various orientations were exposed, taking into account air temperature, radiation and air movement. In conclusion, the paper described a device for integrating and averaging temperature, whereby the mean temperatures of the preceding period could be read directly.

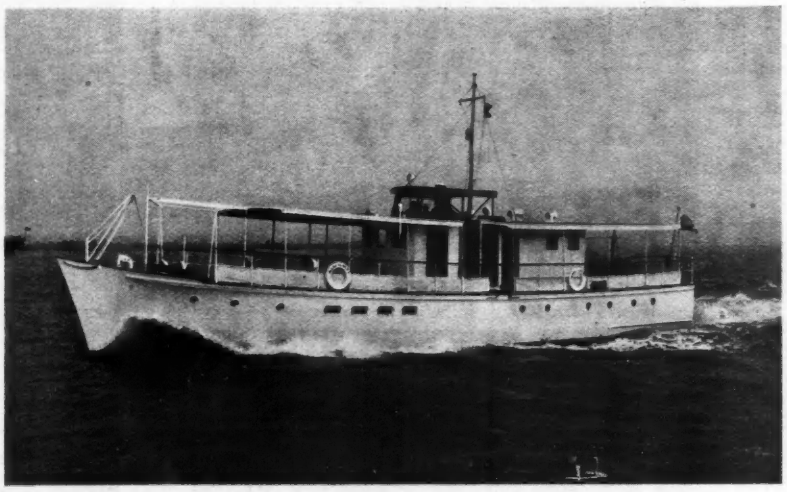
CARGO SHIP ORDER—Mitchell and Rae, Ltd., has ordered a diesel-engined cargo vessel, to carry coal and grain, from Hall Russell and Co., Ltd. The dimensions of the vessel will be: length between perpendiculars, 120ft, by 24ft breadth moulded, by 9ft 6in depth moulded.

The Motor Yacht "Marcalbert"

WE were invited recently to visit the Hampton-on-Thames yard of John I. Thornycroft and Co., Ltd., to inspect the M.Y. "Marcalbert," which the company had just completed for Mr. A. A. Gliksten, who will be using the yacht for cruising from Belize, British Honduras. In spite of a heavy stream and the fact that lifting slings were already in position, a short run was made up-river to demonstrate the quiet running of the engines and the excellent manœuvring qualities of the vessel.

PARTICULARS AND CONSTRUCTION

The new motor yacht, which is one of the largest constructed since the war, has a length of 73ft, a beam of 15ft 6in, and a draught of approximately 4ft 9in. The accompanying photograph of the vessel on trial shows the pleasing lines and also the exceptionally large open deck space. The hull is of round bilge form planked diagonally with a double-skin of Honduras mahogany, having a total thickness of 1¼in; an oil fabric is placed between the skins which are laid on opposite diagonals.



TWIN-SCREW M.Y. "MARCALBERT"

The planking is copper fastened to steamed-bent American elm timbers, of 2in by 1¾in scantling, and spaced at 8in centres. There are three watertight bulkheads, the fore peak and aft peak bulkheads, and the engine-room forward bulkhead, all of which are of mahogany, of double-skin diagonally laid construction. The battery compartment is bounded by gas-tight bulkheads, access being arranged from the engine-room through a hinged gas-tight panel in the upper part of the bulkhead. To provide for easy removal of the engines a section of the deck has been made removable, and steel lifting beams and pillars provided.

ACCOMMODATION

At the aft end of the bow-fronted deckhouse is the owner's stateroom, plainly furnished, containing two large berths and having a separate toilet at the forward end. A refrigerator is housed in a small compartment to port, and on the opposite side is the engine-room entrance, while forward of this, steps, to port and starboard, lead up to the steering shelter. The saloon entrance occupies the forward end of the house and sliding doors give access to a T-staircase which leads to the dining saloon. A characteristic of the design is the roomy fore deck, with ample space for lounge chairs, protected by portable mosquito screens, for which stowage is provided.

Going below deck the spacious saloon is entered from the staircase at the forward end of the deckhouse. Besides the usual fittings there are a cocktail cabinet and a radiogram forward to starboard; aft on the same side a transmitting and radio set is fitted. A hinged door in the forward bulkhead gives on to a small lobby which has baggage and hanging space to starboard, and a toilet to port. Another door leads to a large well appointed galley fitted with a refrigerator, and a hatch over gives direct access to the upper deck. Forward of the galley is the chain locker where stowage is provided for two anchor chains which are accessible through a portable watertight panel fitted in the upper part of the bulkhead.

The crew's and domestic accommodation is situated aft and access to this is by a hatchway on the upper deck; a companion ladder leads down to a lobby which has the crew's toilet to port and, on the starboard side, a maid's cabin fitted with two berths. A door at the forward end of the lobby leads to the crew's cabin, which has accommodation for four, (there being two settee berths and two hinged cots) and is equipped with a small stove and oven. The captain's cabin, in which a unit of the yacht's telephone is fitted, is situated to starboard of the crew's space, access being by means of a hinged door. An aft peak compartment of generous capacity houses the steering gear for the twin rudders, and provides stowage for ropes and fenders.

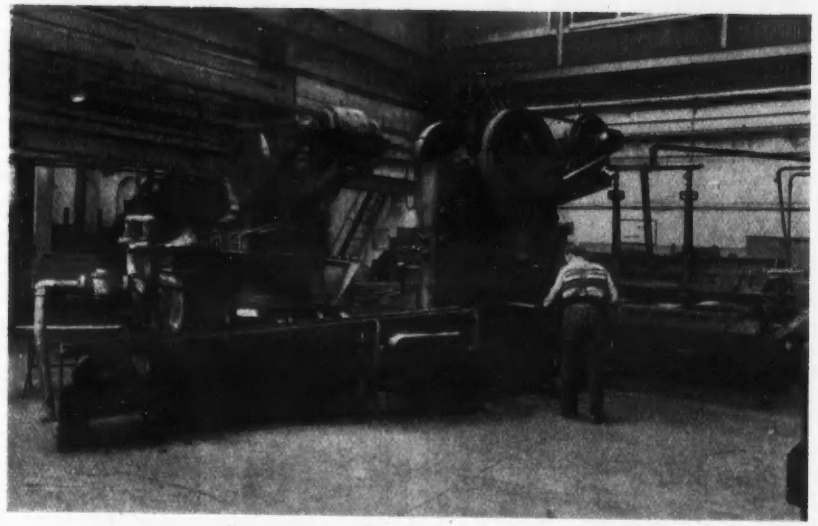
The outside steering position is about amidships; it has a raked bow front, the centre window of which is fitted with a heavy-duty windscreen wiper, and the underside of the roof is heat-insulated. There are a chart table, flag locker, engine controls, telephone and portable gratings, which can be extended to the ship's side rail to assist close navigation. Owing to the tropical conditions in which the yacht will operate, special attention has been paid to ventilation, doors have batten louvres, and mosquito screens have been extensively used. Another unusual feature is the large headroom which has been incorporated in the design; this was a requirement of the owner, who stipulated that the headroom should be 7ft, both above and below decks.

ENGINE-ROOM

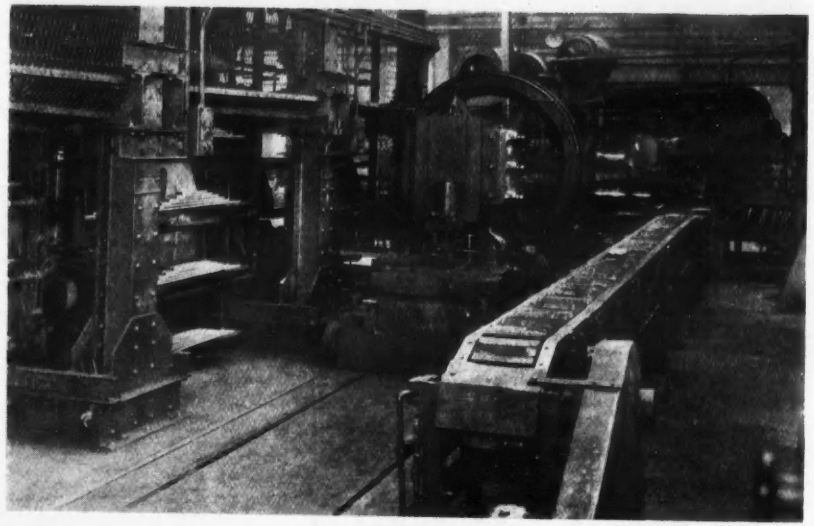
The yacht is propelled by a pair of Thornycroft "RL/6" six-cylinder diesel engines, fitted with a reverse gear and 2 to 1 reduction gear, and driving propellers of 31in diameter by 24½in pitch. Each unit, controlled by a single-lever system, develops 130 b.h.p. at 1600 r.p.m., which was sufficient to give the vessel a speed of 11½ knots on trials. For normal service the engines will run at 1450

LAMINATED SPRING MANUFACTURE

ENGLISH STEEL CORPORATION LTD., SHEFFIELD



END FORMING MACHINE AND FURNACE



PIERCING PRESS AND ELEVATOR LOADING STATION

SPRING BENDING PRESS

SPRING TRANSFER TO QUENCHING WELL FLATFORM

r.p.m. and maintain a cruising speed of 11 knots. The engines are rubber mounted and have rubber couplings to reduce vibration. Cooling is by distilled water in a closed system and the circulating water is cooled by heat exchangers. A water-injection exhaust system is fitted and the pipes are of rubber.

Dynamos are fitted to the main engines, but for normal lighting purposes a Coventry-Victor single-cylinder diesel engine driving a 3kW d.c. generator is supplied. Four engine-starter batteries are fitted under the flooring forward, and a separate compartment houses the domestic supply batteries of 110 Ah. capacity. Outboard of each engine is a fuel tank of 263 gallons capacity; a third tank of 174 gallons capacity is placed to starboard at the forward end of the engine-room, and is balanced by a 137 gallon fresh-water tank. Additional fresh-water tanks, of 43 gallons, 40 gallons, and 30 gallons capacity, respectively, are situated along the centre line under the saloon floor. The total quantity of oil fuel carried is 700 gallons, and the corresponding figure for fresh water is 250 gallons. The underside of the deck and the forward bulkhead have been lined with "Acousti-pads" to reduce fire risk and to provide a measure of sound insulation.

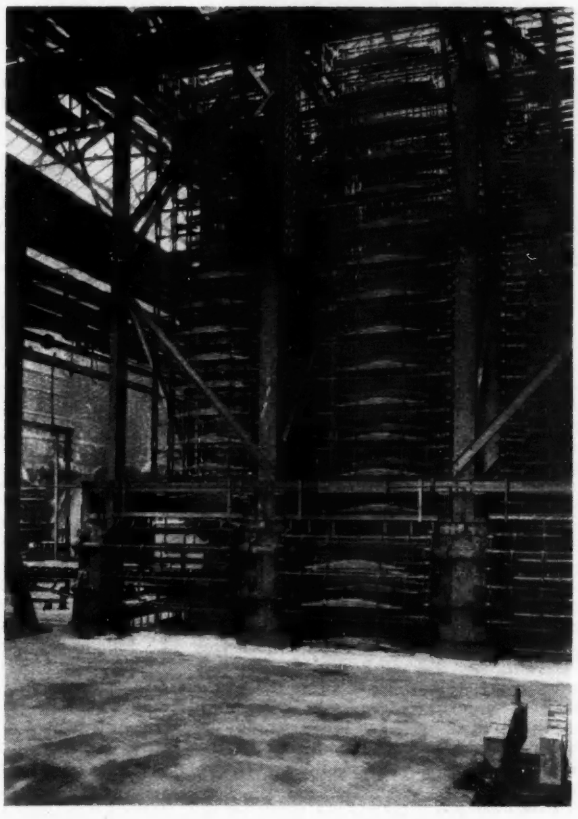
The "Marcalbert" will be shipped as deck cargo to Kingston, Jamaica, and from that point will proceed the distance of 800 miles to Belize, British Honduras, under her own power.

A Mechanised Laminated Spring Manufacturing Plant

LAMINATED springs for railway carriage and wagon stock have for some time past been manufactured in large numbers in a fully mechanised plant laid down at the Sheffield works of the English Steel Corporation, Ltd. This plant was planned by the firm towards the end of the last war, when it became evident that the steadily increasing demands for springs could not be met because of the shortage of skilled labour and lack of suitable unskilled labour for trimming. It was decided, therefore, to develop a mechanical plant for spring manufacture, and, in order to reduce hand work, to use oil-hardening quality steel.

The use of oil-hardening steels was decided upon for a number of reasons, bearing in mind the fact that there is no special advantage in either oil or water-hardened steels from a metallurgical point of view, providing both products are of the best quality. A fact which led to the choice of the oil-hardened steel was that long slender objects such as spring leaves cannot be hardened in water without distortion, whereas the firm considered that with oil hardening distortion would be so much reduced that a method of jig forming and quenching springs would be made possible. In this connection it should be mentioned that when the use of oil-hardened springs is being discussed doubt is sometimes expressed as to the difficulties which may be met in servicing by the mixing of plates of oil and water-hardened steels. It is claimed by the makers, however, that no spring which has been in service should be rehardened, and that any correction which is necessary should be undertaken at a temperature not exceeding the tempering heat for the steel. Where plates have to be replaced in a spring which was made up originally of oil-hardened steel, they can, without detriment, be replaced with plates of water-hardened steel, as the temperatures which would be employed for any future correction, would for all practical purposes be identical.

With oil-hardened steel, hardness can be obtained with a less drastic quench than in the case of water-hardened steels, and this slower rate of cooling has an advantage in that it renders the steel less sensitive to the effects of retardation of cooling by the presence of small amounts of scale or similar factors during quenching. In making the springs by the system developed at the English Steel Corporation's works, mill scale is broken up and falls away during the bending operation, and the quick transfer into the quenching oil, made possible by mechanical handling, reduces the formation of new scale to a minimum.



UNLOADING SIDE OF FIRST STORAGE ELEVATOR UNIT

The spring-making plant, some views of which are reproduced on this page and page 166, is designed to manufacture springs up to 5ft long, with leaves from 3in to 5in thick and weighing not more than 3 cwt.

Steel stock in the form of flat bars of the width and thickness of the spring leaves and 16ft to 18ft long, is fed into the plant from a large store at one end of the spring shop. The first operation consists of shearing the bar stock into the required lengths for leaves. At this stage all the longest leaves required for the batch of springs required are cut off first, then all the second longest leaves, and so on, down through the full range of leaf lengths. As each leaf is sheared off the bar it is loaded straight on to a continuous end-heating furnace, and during its passage through this furnace about 6in at one end of the leaf is heated to approximately 800 deg. Cent. In the subsequent end-forming operation in a press the heated end of the leaf is speared and the nibs and slots, which serve to prevent sideways movement of the leaves when a spring is in service, are formed. The leaf is then placed in a second continuous end-heating furnace and its opposite end heated before undergoing similar treatment in a second press. As it is removed from the second press the leaf is placed in a third continuous furnace in which its centre section is heated ready for the punching of the centre hole.

In one of the photographs we reproduce on page 166 is shown the first end-forming press with its continuous furnace at the side. The three furnaces used for heating the ends and centre of the leaves are of the concentrated combustion type, in which the full heating effect of a series of gas burners is concentrated on the actual area it is required to heat.

The centre hole punching machine, on which the last forming operation on the leaves is performed, is mounted on rails and can be moved transversely along the front of three special storage elevators. The leaves are fed to this press from the furnace on a slat conveyor along which the feed can be maintained constant without men handling leaves, irrespective of the position of the press or the track.

At this stage of manufacture the leaves have to be assembled into "packs" to form a complete laminated spring, and the storage elevators have been specially designed to simplify this operation as well as to conserve floor space. Three storage elevator units are arranged side by side, the two outer units being designed to accommodate 420 "packs" and the inner unit 386 "packs." Each unit consists of a series of rising and falling vertical chains fitted at intervals with carriers on which the leaves are assembled. On the two outer elevator units the carriers are so spaced that springs with up to eight leaves can be assembled, and on the centre unit the carriers take springs with up to thirteen leaves.

It will be remembered that in each batch of springs all of the longest leaves are made first and the succeeding lengths in subsequent batches. When the final centre piercing operation has been completed on a leaf it is placed on a carrier and a push-button switch is depressed by the machine operator. The elevator then advances one stage to bring the next carrier into the leading position. When all the long leaves have been placed on the carriers the next in length begin to feed down from the first operation machines. In this way each succeeding length of leaf is fed to the conveyor and loaded on top of the pack until each carrier has a complement or "pack" of leaves forming one spring. If the batch of springs on order numbers less than the number of carriers on an elevator the drive is reversed at the end of each leaf length, to save the time which would otherwise be wasted in making a series of idle movements in one direction to bring the first loaded carrier back to the loading station. The centre piercing press and storage elevator loading station can be seen in one of our illustrations. When one elevator is fully loaded the piercing machine is moved along to another of the three units. With this arrangement of three storage units, whilst one is being loaded a second one can be discharged, and, if necessary, the third can be used to hold a buffer stock.

The storage elevators are discharged on the opposite side to their loading stations, and the "packs" are fed in turn to a reheating furnace. The process of transferring the "packs" from the elevator to the reheating furnace is controlled through a system of interlocks by a master timing clock.

In the cycle of operations the elevator is automatically started and stopped to bring a loaded carrier into line with a roller conveyor

running transversely across the line of elevators and passing into the feed end of the reheating furnace. This reheating furnace is of the walking beam type, and its frequency of operation is controlled by the master clock. Whilst the feed rolls of the roller conveyor are stationary a transfer mechanism removes a "pack" from the elevator carrier and places it on the rolls. When the beams in the furnace have completed a movement and come to rest they operate a switch which energises the feed conveyor roll drive and a spring is carried into the furnace. As the spring passes the furnace entrance it breaks the light ray operating a photo-electric cell, which energises a clock set at a predetermined timing. This timing is arranged to give the spring time to travel into the required position in the furnace before cutting out the feed roller drive. The spring stops in this position until the beams of the furnace pick it up on the initial stage of the passage through the furnace.

According to their length spring "packs" are fed into the furnace to pass through as a single row or in pairs end to end, and the feed mechanism can easily be set for either type of feed. At the discharge end of the furnace a line of rollers runs continuously and with each cycle of the beams carry a spring out of the furnace.

As each spring is discharged from the furnace it passes on to the table of a straightening press which squeezes the "pack" of leaves edgewise before it passes along a short roller conveyor to the bending press. A transfer gear removes the spring from the conveyor and places it on the hydraulic bending press, which is shown in another of our illustrations. At the end of the bending operation and whilst the spring temperature is still 920 deg. to 950 deg. Cent., a "roll-over" mechanism automatically removes the spring and delivers it on to the platform of a quenching oil well in which a large volume of oil is constantly circulated.

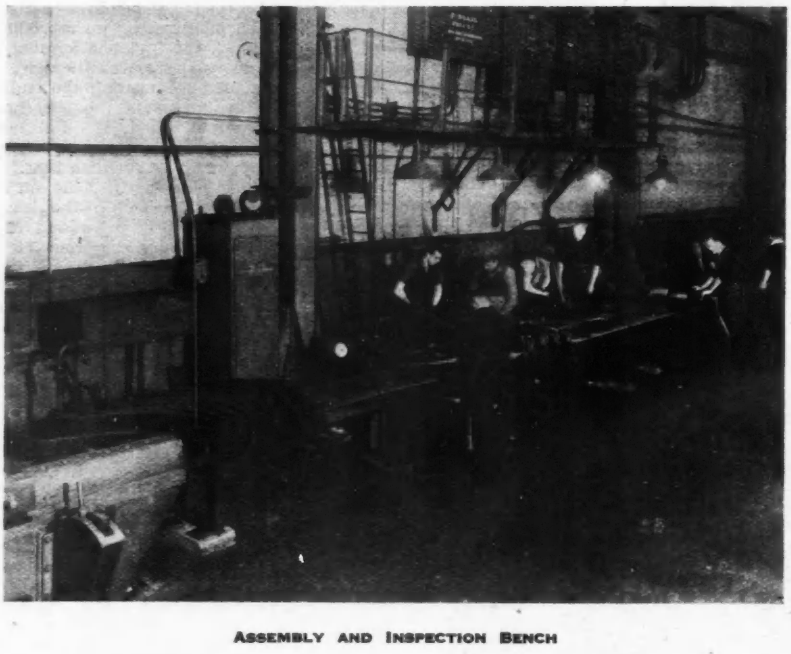
On this platform the spring is "broken" and its leaves loaded individually into specially designed cribs mounted on the sides of a hexagonal drum which rotates in the well. Each crib member is set to accommodate one length of leaf which is firmly gripped at a number of points between studs. As a leaf is set in its crib the operator trips a lever, and the crib members carrying the studs are closed in on the leaf under the load of a heavy spring and toggle gear. With the leaf firmly gripped to prevent distortion the quenching drum rotates one station to plunge the leaf beneath the surface of the oil and bring the next crib to the loading point.

When each loaded crib reaches the lowermost point in the drum's rotation, its toggle locking gear is tripped by a solenoid-operated ram and the spring leaf drops on to a conveyor belt at the bottom of the well. This conveyor belt carries the leaf up an inclined path to the loading platform of a tempering furnace, and during this movement the surplus oil draws back into the well.

The loading platform of the tempering furnace can be seen in the rear of the quenching well in one of the photographs we reproduce. On this platform all the leaves of a spring are marshalled into a full set before they are placed in the furnace. The tempering furnace has a the continuous mattress, with recirculated hot air, and it is operated at a temperature of about 500 deg. Cent. At the discharge end of the tempering furnace the sets of leaves slide at regular intervals down a chute into a tank of cooling water through which they are carried by a belt conveyor. At the far end of the tank the belt carries the leaves up an incline and deposits them at the head of a long assembly and inspecting bench.

On the bench each spring is first greased and reassembled and then inspected for the general close fitting of its leaves. This operation is carried out in a press which grips the centre of the spring in such a way that it can be turned over to enable close inspection of both sides. At this stage any small corrections which are necessary are made by spring fitters and the spring is put straight back into the line. A bolt or strap is then fitted to hold the leaves together, whilst a "scrag" or deflection test is made on the spring. In this test the spring is deflected to a predetermined degree in a special horizontal press, and afterwards the camber is checked. Springs which pass the test are loaded on to the carriers of one of two storage elevators of similar design to those used in the assembly section.

At the opposite side of the storage elevators the springs are automatically discharged on to a stock table in the hooping section. In this section the temporary bolt which was used to hold the leaves together for testing purposes is removed and a hot mild steel or iron hoop placed round the centre. A rivet is then driven through the hoop and spring and closed before the hoop is squeezed into firm contact with the spring on all four sides on a hydraulic press. After hooping the springs are loaded on to a third storage elevator to wait further scragging and final inspection. After final inspection the springs are transferred to lines of bench conveyors for painting before being loaded into wagons for dispatch.



ASSEMBLY AND INSPECTION BENCH

With the exception of the reheating and tempering furnaces, which were supplied by Stein and Atkinson, Ltd., and the elevator conveyors, which were supplied by the Moxey Conveyor and Transporter Company, Ltd., practically all of the equipment used in this plant was designed and built at the works of the English Steel Corporation, Ltd., or made to its special requirements.

The Wenvoe Television Transmitting Station for the Bristol Channel Area

AFTER negotiations for a site for a high-power television transmitting station to serve the Bristol Channel area, the B.B.C. has now arranged to buy land on St. Lythan's Downs, near Wenvoe, about 5 miles to the west of Cardiff. The site has been approved by the Postmaster General and the station will be known as the Wenvoe Television Transmitting Station.

Twelve sites that looked promising were investigated. Nine of them were eventually turned down, leaving only one district in South Wales and two in Somerset to be examined in more detail. Field-strength tests were then made by the B.B.C. Engineering Research Department from these three places. A mobile 1kW transmitter was set up at each in turn with an aerial suspended from a balloon 600ft above the ground, and a field-strength measuring van toured the surrounding country, making a record of the received signal strength. From these records field-strength contour maps were prepared, showing the probable service area of a high-power transmitter at each site.

The Wenvoe site is 400ft above sea-level and covers an area of about 25 acres near the Cardiff-Swansea road in the parish of St. Lythan's. On it will be constructed a building for the transmitters, a substation and a 750ft mast similar to the one at Sutton Coldfield. The contract for the mast has been awarded to British Insulated Callender's Construction Company, Ltd., and for the buildings to Gee, Walker and Slater, Ltd. The vision and sound transmitters were ordered in January, 1950. The vision transmitter, which is being designed and manufactured by Electric and Musical Industries, Ltd., is to have a power of 50kW and the sound transmitter by Standard Telephones and Cables, Ltd., will have a power of 12kW. An innovation in the design of the vision transmitter is that the carrier wave will be modulated by the vision signal in a low-power stage instead of in the output stage, as has been customary in previous television transmitters.

It is expected that the boundary of the service area of the Wenvoe station will be approximately along a line through Barnstaple, Teignmouth, Swanage, Marlborough, Chepstow, and slightly to the north of Brecon, Carmarthen and Tenby. This area has a population of 3½ million and among the principal towns within it are Tenby, Carmarthen, Llanelly, Swansea, Cardiff, Bristol, Bath, Dorchester and Taunton. Some parts of the country within this area are mountainous and in those parts the quality of reception may vary considerably from place to place.

A SMALL HYDRAULIC ARBOR PRESS.—The "Hydroram" hydraulic pump and ram units made by Chamberlain Industries, Ltd., Staffa Road, London, E.10, have been adapted for a wide range of applications, the latest of which is a compact arbor press. This press, which is designed for a maximum load of 5 tons, consists of a rigid fabricated steel frame with a work table 7½in square. The pump unit, mounted at the side of the frame-base, has a stroke of 6in and is operated by a conveniently arranged ball-handled lever. Pressure fluid is supplied to the ram unit above the work table through flexible tubing and each stroke of the pump gives a ram travel of $\frac{1}{16}$in. The surface of the table of the press is accurately machined for the attachment of tools for such work as bending, clamping, shearing, &c.

The Fourth Congress on Large Dams

In the following paragraphs a brief summary is given of the questions which were discussed at the Fourth Congress on Large Dams, which ended in New Delhi on January 12th. The Congress was organised by the International Commission on Large Dams, a body associated with the World Power Conference, and took place at the same time as two other international engineering conferences in New Delhi, namely, a sectional meeting of the World Power Conference and a conference of the International Commission on Irrigation and Canals. The four questions discussed at the Congress were concerned with flood discharges and spillway design (Question 12), earth and rock-fill dams (Question 13), silting of reservoirs (Question 14), and concrete for large dams (Question 15). A general report of the papers in each of these sections was prepared, each report containing a list of the papers concerned, and the details which we give below have been abstracted from these general reports.

Question 12

This question was concerned with methods for determining the maximum flood discharges which may be expected at a dam; moderation of floods through reservoirs; spillways for high dams; selection of type and general arrangement of temporary or permanent outlets; stilling basins for spillways and pressure outlets; gates and valves; and problems of stream diversion and closure during construction. Forty-two papers were submitted from twelve countries, and the general report was by Kanwar Sain, member of the Central Waterpower, Navigation and Irrigation Commission, India.

This report noted that flood discharge for a dam should be calculated for each individual case, taking into account all the known observed data. To supplement insufficient local data, certain general considerations resulting from observations on rivers could be used. Several of the papers discussed formulæ of probability and empirical formulæ used for flood prediction and the use of observed data in making calculations with such formulæ was commented upon. The topic of the moderation of floods through reservoirs was dealt with along similar lines.

The papers concerned with spillways gave details of the design of many types, including, for example, the ski-jump spillways of some French dams, the stepped spillway of the Eupen dam in Belgium, volute-siphon spillways and round crest, siphon and trumpet-shaft spillways. The magnitude of floods, cost of structure and cost of repairing damage, were examined in one of the papers. A similar treatment was given to the selection of type and general arrangement of outlets and to stilling basins for spillways and for discharge from outlets. Several examples were given of the gates and valves on various projects, and problems concerned with diversion during construction at six dams in the U.S.A. were described in one paper.

Question 13

The general report on this section, which covered the design and construction of earth dams and rock-fill dams, with their core walls and diaphragms, was by William P. Creager, consulting engineer, U.S.A. Unlike the other questions before the Congress, which covered specific divisions of general subjects, Question 13 covered the general subject of earth dams and rock-fill dams with all its subdivisions. The general report was therefore compiled under the headings of history; suitability of site; design of earth dams; earthquake forces; seepage and drainage; impervious barriers; slope protection; construction of earth dams; filters; rock-fill dams—design and construction; settlement of dams; spillways and floods; and taking care of water during construction. The topics for discussion suggested by Mr. Creager at the end of the general report indicated that there exists some diversity in the methods of design and construction of these types of dams.

There were twenty-three papers submitted for Question 13, from ten countries, and two further papers on the same topic were included in the six "communications," which arrived too late to be sent to the author of the general report.

Question 14

Question 14, on the silting of reservoirs and related problems, gave rise to a series of papers, all of which, according to the general reporter, Georges Drouhin (Algeria) were interesting and quite a number of which made contributions of real importance to the study of the subject. There were altogether sixteen papers from seven countries.

The question was purposely framed in a very general form. Erosion, which produced the materials that caused filling, and the transport of those materials along watercourses, both depended on many natural factors, and variations in those factors not only affected the orders of magnitude but might often change the very processes of the phenomena that occurred. Among such variables were the size of the catchment, its topography and geology and particularly its lithology and climate, &c. Silting in reservoirs and in a general way all changes to valley forms attributable to human works were fundamentally affected by the nature of these works, their technical design and manner of operation. Each author envisaged and reasoned in terms of the natural conditions which obtained in the areas where he himself had worked. The objectives sought after were often very different, such as irrigation, power production, protection against floods, general regulation or a multiplicity of purposes. Some concerned themselves especially with causes, others with effects, others, again, with the techniques of possible remedies, and several with economic considerations. All this variety, Monsieur Drouhin noted, was very useful and a cause for congratulation.

Question 15

Question 15, entitled "Concrete for Large Dams," attracted a total of thirty reports from eleven countries; one further paper was included in the "Communications," having arrived too late for inclusion in the general report. The general reporters for this question were F. M. Lea (Australia) and H. D. Morgan (United Kingdom).

The topics which were discussed were divided by the general reporters into three groups, namely: (1) the effect on the properties of concrete, particularly on extensibility (cracking) and on water-tightness of content and type of cement, and of grading and proportion of fine aggregate with and without air-entraining agents; (2) cracks and absence of cracks in existing dams and appurtenant works; (3) the use in mass concrete of pozzolanic cement, blast-furnace slag cement and hydraulic lime, such as Kankar lime and Surkhi.

While the cracking of concrete and practical steps taken to reduce the effects of cracking were not new in themselves, it was only within fairly recent times that much detailed research had been carried out on the factors involved in the production of cracks. The general reporters noted that, although it was too soon to judge to what extent the group of papers would cause any change in the best techniques available for the construction of large works, it could certainly be said that the significance of the various factors would now be better understood.

In the case of the gravity dam, density rather than high strength was required, apart from the question of water-tightness, which was common to all dams. Density was mainly a matter of cement and aggregate, while water-tightness had an obvious relation with cracking. The design of buttress dams required a higher working stress than for the gravity dam, but certain types of cracking were more easily avoided since the mass of concrete was much less. The designer of arch dams, however, had to use high stresses in his material and, while it was generally easier in such structures to deal with the phenomena accompanying the setting of the concrete, other attributes of the material became highly significant. For example, it would be true to say that creep and swelling or shrinkage of the concrete due to absorption or loss of water, were almost as important as changes of temperature and hydrostatic load, in offsetting the stresses induced in a thin arch dam. It was in those matters that it was thought that the papers might prove of value to the designer.

The disadvantage arising from the use of ordinary Portland cements in mass concrete were well-known and, as had been reported in earlier Congresses, much had been done towards the development of alternative materials, which offered, in particular, lower heats of hydration and improved workabilities of the concrete and greater freedom from cracking. The considerable variety of suitable materials now available was indicated by the general discussions in several papers. Tests on standard Belgian cements containing different proportions of blast-furnace slag, which were of particular utility in mass concrete construction, were described, as was experience in dam construction in the U.S.A. and in Italy with concretes made with a combination of Portland cement and pozzolana. The use of trass admixture in Austrian dams was described, and in India, Surkhi, a powdered, burnt clay, had been used as a pozzolanic admixture to lime mortars from the earliest times and had given satisfactory service in masonry dams; more recently it had been used as an admixture to Portland cement mortar to give the so-called "red cement mortar."

Communications

Eight papers of the Congress were listed as "communications," and were not classified with one of the four questions discussed. As has already been mentioned, two of these papers were concerned with Question 13 and one with Question 15, and arrived too late for inclusion in the general reports of these sections. The five remaining miscellaneous papers were entitled: "The River Mera Dam at Villa di Chiavenna" (Italy), by Marcello; "Extensometric Measurements in the Bed Rock and in the Concrete of a Thin Arch Dam," by Bellier and Chervier (France); "Some Realisations of Syphons," by Rousselier and Blanchet (France); "The Use of Mineralogical Technique in Testing Material for Dams," by Capdecomme, Farran and Orliac (France), and "Gravel Alluvium in Foliation and Pervious Formations," by Cambefort (France).

Gauging Equipment for Gas Turbine Blades

An interesting application of pneumatic gauging has been adopted in an equipment specially developed for checking the contours of gas turbine blades, which has been produced by the Sheffield Corporation of Dayton, Ohio, U.S.A. Particulars of this equipment have been received from Stuart Davis, Ltd., Much Park Street, Coventry, the agents for the Corporation in this country.

The gauging apparatus consists of an assembly of eighteen "Precisionaire" columns, mounted side by side on a panel, as shown in the illustration reproduced below. Each of the columns is connected by a flexible tube to one of the maker's recently introduced "Plunjet" gauging elements. These elements are about 1¼in. long by ½in high by ½in wide and, in the blade gauging unit, are mounted in groups of three on plates to form gauging heads. On a table in front of the panel a number of blocks are assembled to support and locate the gauging element heads round a small fixture which supports the blade to be examined. Six sets of gauging heads are arranged to work in pairs, there being three sets arranged on the internal (concave) and

three sets on the external (convex) sides of the work. A set of gauging elements is positioned at each side of a blade at its upper, middle and lower calibrated points of check.

For setting the gauging heads a selected and calibrated turbine blade is used as a master. When the gauging heads have been clamped in position to register on this master blade feeler gauges can then be used to set the instruments to read for a theoretically perfect blade. Thereafter when blades are being inspected the indicator floats in the gauging columns indicate

BLADE GAUGING EQUIPMENT

the degree each blade varies from a blade of exact theoretical proportions. The thickness of a blade at any point can be checked by comparing the position of the float in an external registering column with that of the corresponding internal registering column.

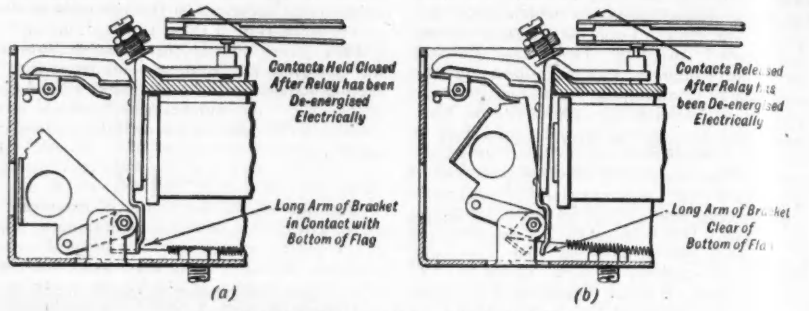
On the equipment illustrated the tolerances on the blades are 0·0025in on the internal points of check and 0·0075in on the external points. The makers state that the fixture could be set for closer tolerances or, if desired, the range could be opened out to 0·020in and 0·010in respectively. The equipment is very flexible and can be adjusted to gauge a wide variety of blades without need for major modification. In the same gauging fixture blades varying by more than an inch in width, height or contour can be accommodated and by altering the fixture it can be adapted for checking more or fewer points on a blade, for blades of a different shape, or for other parts where the same principles of gauging can apply.

An Indicating Relay for Power Circuits

PROTECTIVE equipment associated with electrical power plant should not only disconnect the apparatus causing a fault; it is generally desirable that it should send a signal to the control point concerned, showing that a fault has occurred, indicate in the vicinity of the plant the particular apparatus involved and indicate the nature of the fault.

An indicating relay has been designed by the General Electric Company, Ltd., to perform these three functions in conjunction with protective circuits. Each possible fault condition is allotted a relay and, to allow more rapid identification of the faulty equipment or circuit, the indicating units are generally mounted in rows, the item of plant or the nature of the fault being designated on the front of the unit or on a separate strip.

The complete indicating unit consists essentially of a specially insulated telephone type relay mounted in a metal framework. Referring to the accompanying drawing (*b*), the shorter


Contacts Held Closed After Relay has been De-energised Electrically
Long Arm of Bracket in Contact with Bottom of Flag
(a)
Contacts Released After Relay has been De-energised Electrically
Long Arm of Bracket Clear of Bottom of Flag
(b)

INDICATING RELAY FOR POWER CIRCUITS

arm of a bracket fitted to the armature of the relay is aligned with a pivoted catch, which engages a hinged flag assembly. A spring attached to the bottom of this assembly tends to turn it about the hinged point.

When a fault occurs, the relay coil is energised from the protective equipment and the contacts close [diagram (*a*)] to energise the trip circuits for isolating the faulty plant and send a signal to the control point. As the armature of the relay moves towards the pole-piece, the short arm of the bracket strikes the catch, which releases the flag assembly. The spring rotates the assembly and the face of the flag, which is coloured, appears in a window in the front of the framework, to indicate locally the plant affected or the nature of the fault.

Release of the relay can be arranged to be dependent on either the de-energisation of the coil or on the manual resetting of the flag assembly. When the relay has to be held in an operated position after its operating current has been disconnected, the end of the long arm of the bracket attached to the armature is bent forward so that it meets the bottom of the flag when the relay operates [diagram (*a*)]. The relay itself cannot then be released until the flag assembly is reset. If, however, the long arm of the bracket is bent backwards so that it is well clear of the dropped flag assembly, the relay will be released when the protective circuit disconnects the operating current [diagram (*b*)].

A rod of insulating material projects through a slot in the base of the framework and, when pushed upwards, allows the flag assembly to engage with the hinged catch and to be restored to normal. A common resetting bar can be fitted where a number of relays are mounted in a row.

New Gland for Hydraulic Stop Valve Spindles

By B. COOKE*

A GREAT deal of work to make hydraulic power systems completely oiltight and so reduce the mess with which they are often associated, has been undertaken by the Vickers-Armstrongs Research Department, under the direction of Lt.-Cdr. J. R. D. Walker, B.A. The spindle glands of valves are sources of leakage which have been found difficult to stop.

With the usual soft packing leakage can be prevented by tightening the gland nut, but this greatly increases the effort required to open and shut the valve. Because the packing has little resilience the remedy is of a temporary nature and must be re-applied at intervals. Constant supervision of personnel is necessary to ensure that the glands are maintained in an oiltight condition. In practice such supervision is seldom available; consequently the glands are neglected and a leak results.

Mild steel sleeves were made to fit the stuffing box in place of the packing. These sleeves had "O" seals fitted in internal and

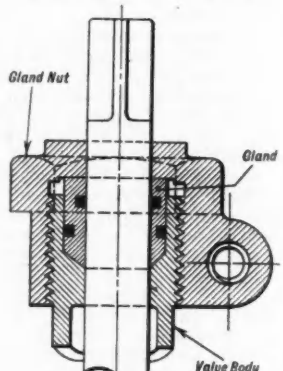


FIG. 2—GLAND IN EXISTING VALVE

external grooves, see Fig. 1. They formed a seal with the spindle and the valve body, respectively. The gland nut was tightened down on to the sleeve only sufficiently to prevent slacking back due to mechanical vibration, as it serves to hold the gland in position see Fig. 2.

Such glands have been used successfully in valves handling mineral oil at 1500 pounds per square inch. The effort to operate such a valve was low. The spiral movement appears to reduce the resistance of "O" seals to rotary or reciprocating motion.

Provided that the spindle and bore of the stuffing-box are in reasonable condition and the tolerances are within those demanded for "O" seals, i.e., 5 thousandths radial clearance, the double "O" seal gland is suitable for retrospective fitting. It seems feasible that where the radial clearance exceeds 5 thousandths the gland would be satisfactory provided that a leather or place backing ring was fitted to prevent extrusion.

For future production a simpler solution presents itself and, although it has not been

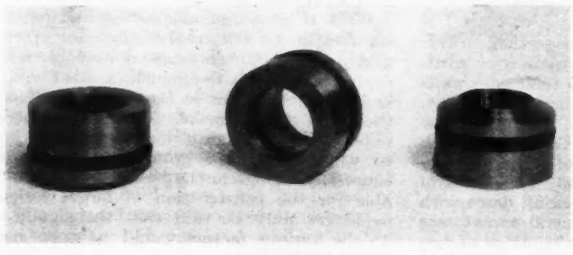


FIG. 1—GLAND FOR HYDRAULIC STOP VALVE SPINDLE

* Vickers-Armstrongs, Ltd., Research Department, Elswick

put to test, there appears to be no valid reason why it should not be equally effective. In place of the usual stuffing box, a groove in the body of the valve can be machined to hold an "O" ring to seal the spindle, (see Fig. 3). To facilitate fitting of the seal whilst the

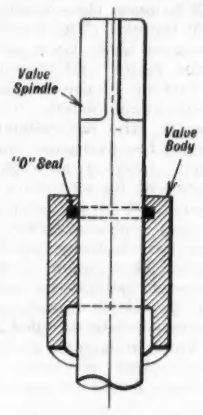


FIG. 3—FUTURE DESIGN

spindle is in position, the spindle aperture could be recessed and a small cover plate provided to complete the groove for the "O" seal.

It is hoped that by publishing this paper the users of hydraulic power systems will benefit by having their systems more oiltight.

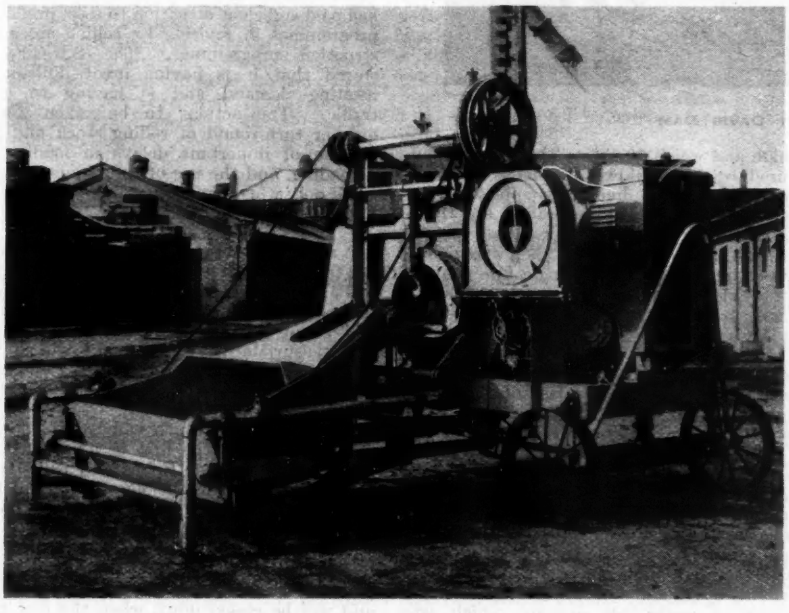
A Batching Unit for Concrete Mixers

IT has long been recognised that in order to obtain the best results in concrete construction close control in the batching of materials is of the utmost importance. For this reason it is now general practice to install a central batching and mixing plant on medium and large working sites. On relatively small sites, notwithstanding the fact that material control is equally desirable, central batching plants are too costly to install and the batching of materials is likely to become a matter of guesswork. In order to provide an economic and easy means of eliminating this guesswork where small quantities of concrete are required, Blaw Knox, Ltd., Clifton House, Euston Road, London, N.W.1, has now introduced an improved weigh batcher which can be fitted to its "Rex" 10 cubic feet and 21 cubic feet (wet) capacity mixers.

When fitted to a mixer the new weigher forms an integral part of the machine against the side of which it can be folded up and firmly secured when not in use or during transport. The weigher is of light compact design and one of the units can be seen fitted to a mixer in the accompanying illustration. It consists essentially of a rigid aluminium alloy tubular frame carrying a weighing cradle, into which the skip nests, and a scale mechanism. The frame and cradle unit is supported at three points in such a way that any twisting effect is avoided when the equipment is set out on uneven ground. Screw jacks fitted on the two outer supporting columns of the frame can be adjusted for general levelling up on site.

The weighing cradle consists of a system of beams, which pivot on roller bearings, and it is coupled to the mechanism of a scale having a large dial fitted with adjustable batching pointers. The weighing unit is mounted on rubber pads on the mixer body and these pads prevent damage being caused to the scale mechanism by vibration when the machine is working or being transported. Sealed roller bearings have been adopted as pivots for the weigh beams, as they can more easily be protected from dust and consequent wear than knife edges. Such bearings are also considered to be more suitable for standing up to hard usage in service and to have a longer effective working life.

The mixer skip, when it is swung up, pivots on pins which register in open top bearings on each side of the drum mouth. In its lowered position on the cradle the skip pivot pins stand clear of the support bearings and it is entirely free of all contact with the mixer. During loading the skip is firmly supported on tubular cross members set between the weigh beams, and as materials are shovelled in their weight is indicated on the scale dial.



BATCHING UNIT WITH SKIP LOWERED

American Engineering News

(From our American Correspondent)

Pipe-Line Crossing the Harlem River

An unusual engineering operation took place in New York recently, when a 568ft long rigid section of pipe-line, weighing 150 tons, was placed at the bottom of the Harlem River by the Merritt-Chapman and Scott Corporation, of New York City. This step completed one of the last works in the New York Metropolitan area for a line to bring natural gas from Texas to the utility companies serving Manhattan, the Bronx, Brooklyn, Queens and Nassau counties. The steel pipe itself was 30in in diameter, ½in thick, and encased in a 3½in jacket of reinforced concrete. Starting at 6 a.m. to take full advantage of tide conditions, three floating derricks were assembled in "single file formation"—the "California" (with 80-ton lifting capacity) the "Monarch" (225-ton), and the "Colossus" (80-ton). The three derricks combined, allowing for 2ft spreaders between the "California" and the "Monarch" and 10ft spreaders between the "Monarch" and the "Colossus," had a combined "hull" of 426ft and a combined lifting capacity of 385 tons. They were to lift the gas main from its shore assembly position on the Bronx side of the Harlem River, and, maintaining precise alignment, to swing broadside across the river and manœuvre it into position above a trench previously prepared in the river bottom, and then to lower it into place. The trench, which was dredged, and in some places cut through rock, was 20ft wide, with its bottom approximately 35ft below the water surface.

With a tug standing by, the movement of the pipe was controlled by winch-operated cables from the three floating derricks. To ease the pressure on the pipe and to ensure its being handled with even stress, three "strong-backs" were fixed to it. The strong-backs for the "California" and the "Colossus" were made up of 85ft derrick booms, with 60ft structural steel trusses to handle the pipe risers on either end. The "Monarch" strong-back was a fabricated steel frame 150ft long. 1in wire cable straps supported the pipe at eighteen points along its length. Acting in unison upon successive signals, the three derricks lowered the pipe 1ft at a time, until it came to rest at the bottom of the trench. Shortly afterwards, two divers went down to inspect the position of the pipe, and to unbuckle the release strings and burn off the end connections with oxy-hydrogen under-water cutting torches. The strong-backs were pulled away and the river was cleared again by noon.

Concrete Encasement of Water Turbine Units

The U.S. Corps of Engineers has announced its use of an improved method of pouring concrete round the scroll casings of water turbines which is said to reduce construction cost and time substantially. The new procedure is being applied to the construction of three 62,500 h.p. machines at Center Hill, and six 62,500 h.p. turbines at Wolf Creek, both projects of the Cumberland River system in Kentucky and Tennessee. With this method, the 135-ton scroll casing of each turbine is embedded in concrete in a single pour, about 24ft deep, and containing 1400 cubic yards of concrete, which is made in one day. Allowing for the time required for the installation of special bulkheads and the performance of other incidental work, construction now requires about one week, compared with five weeks by the previous method, when there had to be three or four-day intervals between as many as ten pours.

The scroll casing and the penstock are first filled with water from the reservoir at full pressure, causing a prestressing of the casing. At the same time, the cool water serves to shrink the casing to a size corresponding to that at actual operating temperature, thus making any special corrections for subsequent elastic deformation unnecessary. The weight of the water in the scroll casing counteracts the hydrostatic uplift of the concrete, permitting a continuous pour without any danger of misalignment. Circulation of water through the casing during concreting helps to dissipate the heat of hydration, which is considerable for such a large pour, and also prevents any distortion of the embedded steel structure due to sudden changes in air temperature.

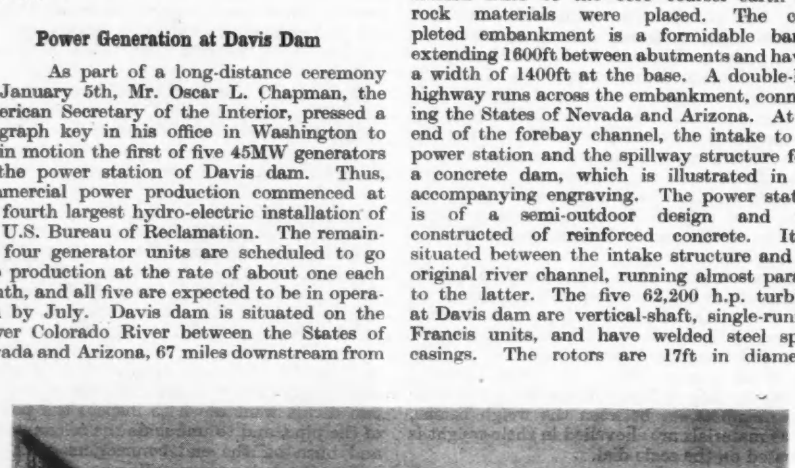
To allow the scroll casing to be filled with water, the top and bottom openings are sealed by two 1¼in thick bulkhead plates, which are bolted to the existing bolt circles of the casing. The top and bottom plates are connected by 2¼in stay bolts, spaced at 30in centres, and

stiffened by pairs of 8in by 11·5 lb channels, mounted back-to-back on the outsides of the plates; ¼in rubber strips are placed along the bolt circles to act as a seal against leakage. Exact positioning of the bulkhead is achieved by means of two eight-legged spiders, one mounted just below the top plate and one just above the bottom plate. Extending vertically through the centre of the bulkhead there is a 6in pipe through which a piano wire is stretched for centre-line alignment checks during the concrete pour. Discharge of the water is controlled by a 6in valve mounted in the lower bulkhead plate. The bulkhead has a total weight of 22 tons. It is made up of commercially available structural steel shapes and does not require machining other than the drilling of the bolt holes. It was designed for a pressure corresponding to reservoir level at the spillway crest, equivalent to a static head of 165ft.

Power Generation at Davis Dam

As part of a long-distance ceremony on January 5th, Mr. Oscar L. Chapman, the American Secretary of the Interior, pressed a telegraph key in his office in Washington to set in motion the first of five 45MW generators at the power station of Davis dam. Thus, commercial power production commenced at the fourth largest hydro-electric installation of the U.S. Bureau of Reclamation. The remaining four generator units are scheduled to go into production at the rate of about one each month, and all five are expected to be in operation by July. Davis dam is situated on the Lower Colorado River between the States of Nevada and Arizona, 67 miles downstream from Hoover dam. Construction of the dam was authorised initially in April, 1941, and a contract was placed in June, 1942. However, because of the outbreak of war, all work ceased late in 1942, and the contract was terminated. In March, 1946, work was resumed by the Utah Construction Company under a new contract amounting to nearly 22,000,000 dollars. The first task under the new contract was the digging of a river diversion, forebay and spillway channel around the Arizona abutment of the dam site. Part of this channel was blasted through rock to a depth of 200ft. The lower end of the channel was lined with concrete and the spillway and the intake structures were built to a level high enough to permit the diversion of the Colorado River through the channel. Cofferdams were constructed across the river above and below the dam site in the summer of 1948, and the river was then diverted. Six openings were left in the spillway, through which the river flowed back into its original channel. These openings were closed in January, 1950, and subsequently filled with concrete to complete the spillway crest. The river then backed up in the channel and forebay area until it reached a level sufficient for it to flow through two outlets, one on each side of the spillway, controlled by means of radial gates. These outlets were closed on November 24, 1950, and, henceforth, all water released must pass either over the spillway crest or through the turbines. When the reservoir—named Lake Mohave, after a local Indian tribe—is filled eventually, it will extend to the tailrace at Hoover dam.

As soon as the river was diverted construction of the dam was started. Davis dam is an earth and rock-fill embankment rising to a height of 138ft above the river bed. Initially, the contractor excavated a cut-off trench approximately 50ft deep across the river bed between the abutments. In and above this trench there was placed an impervious clay core. On both the upstream and downstream sides of the core coarser earth and rock materials were placed. The completed embankment is a formidable barrier extending 1600ft between abutments and having a width of 1400ft at the base. A double-lane highway runs across the embankment, connecting the States of Nevada and Arizona. At the end of the forebay channel, the intake to the power station and the spillway structure form a concrete dam, which is illustrated in the accompanying engraving. The power station is of a semi-outdoor design and was constructed of reinforced concrete. It is situated between the intake structure and the original river channel, running almost parallel to the latter. The five 62,200 h.p. turbines at Davis dam are vertical-shaft, single-runner, Francis units, and have welded steel spiral casings. The rotors are 17ft in diameter, 9ft high and weigh 70 tons. They were manufactured by the Baldwin Locomotive Works under a contract involving approximately 2,300,000 dollars. The generators are three-phase, 60 c/s, vertical-shaft a.c. units, turning at a speed of about 95 r.p.m. They were manufactured by the General Electric Company of Schenectady at a cost of nearly 3,000,000 dollars. It is estimated that the final cost of the Davis dam project, including the dam, the power station and over 1000 miles of transmission lines, will be approximately 114,000,000 dollars. Davis dam is the last of the major structures of the Bureau of Reclamation to be built below Hoover dam within the plans for the development of the Lower Colorado River. One of the main purposes of the construction of the dam was to facilitate the maintenance of treaty provisions between the U.S. and Mexico pertaining to the division of Colorado River waters between the two countries. The treaty required that the dam be built to distribute a regulated delivery of 1,500,000 acre-feet of water per annum, which was apportioned to Mexico under the treaty.



SPILLWAY STRUCTURE AT DAVIS DAM

French Engineering News

(From our French Correspondent)

What will be Electricité de France's largest dam in the Pyrenees is being built at Cap-de-Long. This dam will be 275m long and 100m high and will increase the capacity of an old lake reservoir tenfold. The damming of the water, however, is likely to impede irrigation projects in the region and opponents of the scheme are warning of the danger of erosion if the scheme is completed. Electricité de France engineers, who are collaborating with local engineers to overcome the problem, point out that water at a height of 2000m is highly important for electricity production. Local engineers wish to be assured that they will always have sufficient water for the new canal network which forms part of a large irrigation plan. This plan includes irrigation of hill areas—not valleys—by new reservoirs arranged in a circle round Lannemezan. These reservoirs would be supplied by the Neste Canel, along which broadening work has already started. The problem remaining is to establish a satisfactory distribution of water.

* * *

Equipment for a new, automatic telephone exchange opened in Casablanca, for 3000 subscribers, has cost 77 million francs. In two or three years a new building with a capacity for 10,000 lines will be completed and another with the same capacity is under consideration.

The first step in the plan for French West Africa laid down in 1946 proposed the construction of eight oil plants, using palm oil to overcome the shortage of fats. This plan is in an advanced stage and industrial palm oil is already being produced from the Acobo-Dabou plant. There are now three important plants working: Dabou (capacity 4000 tons, extensible to 10,000 tons), Avrankou (capacity 4,000 tons, extensible to 10,000 tons), Dibombari (capacity 2000 tons, extensible to 4000, then 8000 tons).

The French Equatorial Africa Electric Power Company has undertaken the installation of an hydro-electric plant, using the Djoue Falls, which will give the plant at Brazzaville 30,000 kW installed power and the main, 7500kW, transformers have been ordered.

* * *

A further factor which is now making steel production difficult and is now said to be more important than the shortage of coke and scrap is the lack of sufficient flat, long trucks, capable of removing finished products. In November, total deliveries by rolling mills, by rail and water, were considerably below the output. It is now being asked whether the S.N.C.F. has paid sufficient attention to steel production programmes in revising its rolling stock construction programmes. The S.N.C.F. has stated that it is having great difficulty in meeting demand and is having to divert traffic. The actions to be taken include quicker turn-round of rolling stock and notification of important delays in loading and unloading, and the use of the required type of truck only where no other will do.

* * *

A mains system is to be constructed to carry gas from the coal and steel district of Lorraine to Paris. The first gas mains to be built under the plan will be 300mm in diameter and it will supply gas to Paris, Bar le Duc and Chalons-sur-Marne. This main will have a capacity of 1,000,000 cubic metres of gas per day and work on it will be started at the end of this year.

A second main, which will be laid down as soon as work on the first is terminated, will pass by Verdun and Reims and will join the first line at Chalons-sur-Marne. It will be of the same size and same capacity as the first main.

It is stated that these mains will replace reconstruction work on Paris gas-producing plant, much of which has badly deteriorated and will be closed down when the new mains are working.

Industrial and Labour Notes

Changes in Wage Rates

According to the *Ministry of Labour Gazette*, changes in wage rates which came into operation in the United Kingdom in December last resulted in an aggregate increase of approximately £223,000 in the weekly full-time wages of some 899,000 workpeople.

Taking the whole of 1950, the Ministry of Labour has estimated that 7,350,000 workpeople received increases aggregating £2,020,000 a week, which means that, on the average, wage rates rose about 4 per cent compared with 1949. During that year 5,200,000 workers were given wage increases aggregating £1,076,000. The index of weekly rates of wages (June 30, 1947=100) went up five points, 109 to 114, for all workers in 1950, the biggest advance, 113 to 118, being made in the wages of juveniles. The index for men's wages remained at 109 from January to August, but by the end of last year had risen to 113. The Ministry's figures, it should be noted, relate to wage-earners and not to clerical or other salaried workers. They are based on the rates of wages for a full week and do not take account of variations in actual earnings arising from factors such as overtime or lost time.

The Ministry says that, of the total weekly increase of £2,020,000 in 1950, more than two-thirds was accounted for by increases to workpeople employed in agriculture, the engineering and allied industries, building and contracting, and the distributive trades. It will be recalled that the increases agreed in the engineering and shipbuilding industries became effective as from November 13th last. The Ministry has computed that 1,822,000 workers were affected by them, the aggregate amount involved being £821,600 a week. Another point noted in the Ministry's survey is that, of the total increases throughout the year, 7·5 per cent was decided under sliding scales; 7·5 per cent by arbitration and mediation; 48·5 per cent by direct negotiation; 15·6 per cent by joint industrial councils; 1·6 per cent by other standing joint councils, and 19·3 per cent by wages councils and other statutory wages boards.

Trade Disputes

Stoppages of work through industrial disputes in December last numbered eighty-three, in which 9100 workers were involved and by which, in the aggregate, 28,000 working days were lost. With these figures for December available, the Ministry of Labour has now made a report on stoppages of work through disputes which began during 1950. There were 1338 stoppages of work reported as beginning in the year and, directly and indirectly, they involved 302,000 workers, with the result that 1,388,000 working days were lost. In 1949, there were 1426 stoppages of work reported, affecting 434,000 workpeople and causing a loss of 1,807,000 working days.

About the stoppages of work in 1950 the Ministry of Labour says that the coal-mining industry accounted for nearly one-third of the aggregate loss of time. About three-quarters of the loss at coal mines occurred in the Scottish region. In July last some 170,000 days were lost by over 26,000 workers at various Scottish collieries in support of a demand for an increase in the wages of lower paid workers. Alleged delay in settling the demand led to a further stoppage of work during the latter part of September and the beginning of October, in which approximately 25,000 working days were lost and more than 8000 workers were involved. Dissatisfaction with an award by the coal industry's National Reference Tribunal, concerned with the wages of lower paid workers, resulted in a third stoppage of work at several Scottish collieries at the end of October last, affecting about 10,000 workers and causing an aggregate loss of 32,000 working days. The Ministry has calculated that stoppages in the engineering, shipbuilding, vehicles, iron and steel and other metal industries accounted for rather more than one-fifth of the total time lost last year. There were no stoppages involving very large numbers of workers in this group of industries, though more than 35,000 working days were lost during February and March by about 1500 workers in motor vehicle manufacture, who objected to a shop steward being declared redundant.

Rearmament Problems

In the course of his annual statement as chairman of Lloyds Bank, Ltd., Lord Balfour of Burleigh directs attention to some of the problems created by the Government's rearmament programme. This additional burden, he says, is one that our policies of the last five years have done little to fit us to bear, and that applies both to the finding of the necessary resources of labour and materials and to the finding of the necessary money.

Lord Balfour thinks that any suggestion that the additional output needed for rearmament may come simply from a continued rise in productivity per head is highly optimistic. To a large extent, he says, the recent rise in productivity has reflected the elimination of bottlenecks and the smoother flow of production. It is, therefore, likely to be halted by the dislocation inseparable from a large-scale change-over to defence production. There is even some question, the statement continues, as to whether we shall be able to keep our labour force fully employed in the face of incipient shortages, not only of imported materials but of the one important raw material we should be able to produce at home, namely, coal. Even the supply of steel, in spite of the industry's wonderful production record, is once again a bottleneck.

But, Lord Balfour goes on to say, it would be absurd to suggest that there is no slack in our economy. The fact that virtually every employable person is on somebody's payroll does not mean that production is running at the absolute maximum when most industries are working a five-day week. The labour force itself may be capable of expansion through the attraction of women back to the factories—distasteful though the social implications of that would be—or by the employment of redundant European workers. In such ways, Lord Balfour suggests, but above all by an increase in individual effort, including, if necessary, the working of longer hours and multiple shifts, it is undoubtedly possible to expand production, given the necessary supplies of raw materials, fuel and power. It is another question, the statement adds, whether such additional production can possibly be sufficient to take care of defence demands and it is even more doubtful how the extra output is to be secured in the industries where it is most needed.

Sheet Steel

Several questions on sheet steel supplies were addressed to the Minister of Supply, Mr. G. R. Strauss, on Monday last, in the House of Commons. In reply, the Minister said that no improvement in the position was likely until the new plant in South Wales came into operation later this year. Production from that plant would also increase supplies of flanging quality plate and strip.

The Minister was then asked for his estimate of the shortage on American shipments of sheet steel to this country during the present quarter. On this point, he said that orders for 29,000 tons were outstanding on mills in the U.S.A., of which 21,000 tons were due for delivery in 1950, the remaining 8000 tons having been ordered at various dates for delivery in the first quarter of 1951. So far this quarter, Mr. Strauss stated, 1000 tons had arrived in the United Kingdom and about 3000 tons were in transit, but it was impossible to estimate what the total arrivals for the quarter would be. The American firms which had taken on the contracts had, of course, been asked to make delivery, but they had said that in view of the pressure on them for delivery in other quarters—particularly for defence orders—they could not guarantee when they would be able to deliver the metal.

Zinc Supplies

The Minister of Supply, Mr. Strauss, announced in Parliament on Monday last that zinc allocations were at present being made monthly, the percentages being based on consumption in the first nine months of 1950. For the month of February, the following percentages had been decided: good ordinary brand zinc, 50; electrolytic, 80 (for brass), and 70 (for rolled products and zinc oxide), and high purity, 80. The Ministry had already intimated that firms would be advised by the Director of Non-Ferrous Metals of the actual amounts allocated to them. Those amounts might not correspond exactly with the percentages given since some individual adjustments would probably be necessary.

Time Rates and Hours of Labour

The Ministry of Labour has now published, through H.M. Stationery Office, a report entitled "Time Rates of Wages and Hours of Labour, October 1, 1950." It is the fifth annual edition of a volume which shows, for the more important industries and occupations, the minimum or standard time rates of wages as fixed by voluntary agreements, by joint industrial councils and similar bodies, or by statutory orders under the Wages Councils and similar Acts. In addition to time rates, the report gives particulars of normal working hours and, where available, the basic rates for piece workers and the additional rates payable to shift workers and night workers. Brief details are also given of arrangements, where they exist, for a guaranteed weekly wage. The Ministry points out that, in making use of the volume as a source of reference, it is important to bear in mind that the information contained in it relates to the position at October 1, 1950.

The price of the report is 4s. 6d.

Coal Production

Output of deep-mined coal in the week ended January 27th amounted to 4,207,700 tons, which with 194,400 tons from opencast workings gave a total production for the week of 4,402,100 tons, compared with 4,407,400 tons in the week ended January 20th, and 4,383,200 tons in the week ended January 28, 1950. These figures are given in the latest statement from the Ministry of Fuel and Power, which also shows that, in the first four weeks of this year, coal production amounted to 16,834,800 tons, compared with 16,998,500 tons in the corresponding period of last year. During January this year, 162,500 tons of coal were imported into this country.

Inland coal consumption in the week ended January 20th was 4,504,000 tons, and exports and bunkers required 173,000 tons, giving a total consumption in that week of 4,677,000 tons. Distributed stocks at the end of that week were 10,652,000 tons, compared with 13,455,000 tons in the corresponding week last year. A statement on Tuesday last by Mr. Robens, Parliamentary Secretary to the Ministry of Fuel and Power, said that the decline in coal stocks for the first three weeks of January was 1,800,000 tons, or nearly 550,000 tons more than in the comparable weeks of 1950. The fall in stocks this year, therefore, was at a rate considerably in excess of that usually experienced. Colliery manpower in the week ended January 20th increased to 692,900, of whom 286,100 were working at the face, but absenteeism, voluntary and involuntary, was, at 15·17 per cent, higher than in the preceding week.

Notes and Memoranda

Air and Water

ALUMINIUM ALLOY AND A CARGO VESSEL.—The Aluminium Development Association has issued No. 29 of its Reprint Series, which is a reprint of an article by Mr. W. Muckle and Mr. G. L. R. Watkins, entitled "The Structural Application of Aluminium Alloy to a Shelter Deck Vessel." The authors have calculated scantlings in aluminium alloy for a vessel of 6200 tons deadweight of composite construction and in a series of tables give comparative stresses and weight saving for varying degrees of the application of aluminium alloy to the ship's structure. A final section reviews the economic considerations and a graph is given from which it is possible to ascertain the percentage profit on the additional cost when linked with a known time charter rate.

LLOYD'S REGISTER WRECK RETURNS.—Lloyd's Register of Shipping wreck returns for the quarter ended June 30, 1950, show that forty-six ships of 63,984 tons gross were lost due to casualty or stress of weather, including forty-four steamers and motorships, aggregating 59,461 tons gross. Six of the ships, representing 15,742 tons gross, belonged to Great Britain and Northern Ireland. Ships broken up through causes other than casualty or stress of weather totalled fifty-six, of 165,424 tons gross, of which fifty-three, representing 154,643 tons gross, were steamers and motorships. Of these twenty ships, having a total of 40,629 tons gross, were owned in Great Britain and Northern Ireland. The gross reduction in the world mercantile marine from all causes during the quarter was therefore 102 ships, having a total gross tonnage of 229,408.

Miscellanea

CONSETT IRON COMPANY'S EXTENSION.—In describing the development scheme of the Consett Iron Company, Ltd., on page 18 of our issue of January 5th, we omitted to mention that the main contractor for the water-tube boiler plant was Clarke, Chapman and Co., Ltd., Gateshead.

THE BUILDING CENTRE.—The Building Centre—at present housed at 9, Conduit Street, Mayfair, W.1—has secured more spacious premises in Store Street, Tottenham Court Road, W.1. The Council says that the building needs certain alterations and repair of war damage and it is, therefore, not possible yet to determine how soon the Building Centre can be transferred to it. It will, however, ultimately, provide increased space for permanent exhibits as well as better accommodation for lectures and special exhibitions.

THE DAGENITE "DUAL-LIFE" BATTERY.—We learn that the Dagenite "Dual-Life" battery is again being marketed after an absence of many years. In this battery plate separation is by an envelope of microporous plastic material, which encloses the negative and, thereby, eliminates internal short circuits. Although the separator envelope is tough it is sufficiently porous to allow free passage of the acid. Compared with its pre-war equivalent the new "Dual-Life" battery is stated to have better performance characteristics and longer life.

TIME-TESTING OF NEW BUILDING BLOCKS.—The practical value of any new type of building block is dependent on the construction time of buildings for which the new block is used. As it is not always possible to keep full records of the time taken to build full-scale houses by a new method an alternative method, in which a small-scale test wall is built, can be used to provide the information needed. The National Building Studies Technical Paper No. 9, "Test Walls for Assessing Construction Times with New Building Blocks," published by H.M. Stationery Office, price 9d., gives details of such tests carried out at the Building Research Station, and the results they have given.

THE A.S.E.E. DIPLOMA SCHEME.—Certain changes have been made in the operation of the scheme which was introduced five years ago to govern the award of the Swann Diploma by the Association of Supervising Electrical Engineers. In future there will be separate examinations and diplomas for electrical installation practice and electrical maintenance, respectively. Professor R. O. Kapp, B.Sc., M.I.E.E., has retired from the position of chief examiner, and Dr. F. T. Chapman, C.B.E., D.Sc. (Eng.), has been appointed in his place. A revised brochure giving particulars of the scheme and the syllabus of the Swann Diploma examinations can be obtained from the General Secretary, Association of Supervising Electrical Engineers, 54, Station Road, New Barnet, Herts.

WATCH TESTING AT THE N.P.L.—It has been announced that on March 1st next the Kew "A" tests will cease. From that date tests at the National Physical Laboratory will be made by means of equipment capable of recording errors as small as five-thousandths of a second. A quartz-oscillator clock will provide the standard of time required and an electronic device will measure the errors with accuracy. The Kew "A" test was inaugurated at Kew Observatory in 1884 at the request of the British watchmaking industry, and the publication of a yearly list of the best watches tested in order of merit provided a stimulus to improve watch design and manufacture. In 1912 the National Physical Laboratory took over responsibility for the tests and the issuing of certificates. The "A" tests are being abandoned because of demands for even greater accuracy in watch testing than they have provided. They will be superseded by two new tests, the "Craftsmanship Watch Test" for precision watches, and the "Sporting Watch Test." The National Physical Laboratory Stop-Watch Test will also be revised.

TRAINING COURSES IN CONCRETE.—During 1950 the Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W.1, carried out a series of refresher courses to give training in certain new uses and applications of concrete and in the control and production of high-quality concrete. The Association has decided to offer similar facilities each year and details of the programme arranged for 1951 have been arranged. The courses will be held at the Association's training centre near Slough, Buckinghamshire, and will take place at various times throughout the year from next April. Each course will last four and a half days, and the titles of the various courses are: The Basic Principles of Making Concrete and Controlling its Quality (for engineers and architects); Uses, Properties and Methods of Making Prestressed Concrete (for engineers and supervisors); Modern Methods of Concrete Road and Pavement Construction (for engineers); Concrete Construction (for supervisors); The Use of Concrete in Farm Buildings (for architects, engineers, surveyors and officials concerned with farm buildings); and Modern Developments in Concrete Technique (for engineers and architects).

BUILDING APPRENTICES' SCHOLARSHIPS.—The Ministry of Works announces that applications are invited for the Welfare Fund Scholarships of the Building Apprenticeship and Training Council. Scholarships will be tenable for three years at a university or technical college offering a degree or higher diploma course in building science. Candidates for university courses must be at least seventeen years old (sixteen for diploma courses) on March 31, 1951. Application must be made through, and supported by, the recommendation of the principal or head teacher of the educational institution at which the candidate is attending or has attended. The form of recommendation will be forwarded to the local Joint Apprenticeship Committee for comments. In the case of part-time building students or ex-students the form will also be sent to the employer, so that he can add his observations. The closing date for receipt of recommendations is March 31st. Notes for the guidance of principals and head teachers nominating candidates, forms of recommendation, and leaflets setting out the arrangements fully, may be obtained from the Building Apprenticeship and Training Council, Lambeth Bridge House, Albert Embankment, London, S.E.1.

GROUP-DELAY MEASURING EQUIPMENT FOR THE BRITISH POST OFFICE.—Phase distortion is present in all telecommunication transmission systems, but is not noticeable in carrier-telephone or music circuits because even large distortions in phase cannot be detected by the human ear. In television transmission systems, however, phase distortion becomes of paramount importance because its effect can be seen on a television screen; its accurate measurement is therefore a necessity. Two sets of equipment for measuring phase distortion have already been designed and manufactured by the General Electric Company, Ltd., for use on the London–Birmingham television radio-relay link. The Birmingham–Manchester and London–Cardiff coaxial-cable television links, for which the G.E.C. is supplying the repeater-station amplifiers, will soon be undergoing initial tests, and a further set of eight phase measurement equipments has been ordered. Each equipment will provide direct-reading measurements of the group delay of a 120 kc/s band in the vision-frequency band-width, the measurements being made to an accuracy of 0·005 micro-second. A pilot comparison frequency is transmitted through the system being measured so that the equipment could be used on systems with terminal stations several hundred miles apart.

Personal and Business

MR. C. E. WURTZBURG has been nominated President, and Viscount Runciman, Vice-President, of the Chamber of Shipping.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., announces the retirement of Mr. A. Sargent, works manager at the Helsby works since 1946.

MR. WILLIAM BROWN, general works manager of the Dagenham and Monk Bretton works of W. J. Fraser and Co., Ltd., has been appointed a director of the company.

MR. W. E. A. REDFEARN, a special director of English Steel Corporation, Ltd., has been elected Chairman of the Alloy Steels Association in succession to the late Major Guy S. Newton.

GEORGE COHEN, SONS AND CO., Ltd., states that the raw materials section of its Newcastle-upon-Tyne branch has been transferred to Coborn Works, Hebburn-on-Tyne (telephone, Hebburn 32331).

THE CONVEYANCER FORK TRUCK COMPANY has now been registered as a separate division of Electro-Hydraulics, Ltd., Warrington, and Mr. E. P. Holmes has been appointed chief industrial engineer.

MR. H. A. JOHNSON, formerly chief mechanical engineer of the Gold Coast Railways, has been appointed technical representative, railway division, of British Timken, Ltd., in Australia and New Zealand. His office will be at 473, Bourke Street, Melbourne, C.1, Australia.

MR. W. C. F. HESSENBERG, M.A., F.I.M., has been appointed deputy director of the British Iron and Steel Research Association, of which Sir Charles Goodeve, F.R.S., is director. Mr. Hessenberg will continue to serve as head of the Association's mechanical working division.

MR. L. H. COOPER has been appointed chairman, and Mr. L. K. Brindley, managing director, of the Mond Nickel Company, Ltd. Mr. G. Archer and Mr. A. Parker Hague continue as directors, and Mr. I. A. Bailey, Dr. L. B. Pfeil and Dr. A. G. Ramsay have been elected to the board.

MERZ AND MCLELLAN (SOUTH AFRICA), Escom House, Rissik Street, Johannesburg, announce that they have taken into partnership Mr. Harold J. Beard and Mr. T. R. J. Bishop, in addition to the partners of Merz and McLellan and the present resident partner, Mr. S. G. Redman. Mr. Bishop is also resident in South Africa.

MR. LESLIE FLATT, M.I.C.E., M.I.Mech.E., has been appointed technical consultant to the United Steel Companies, Ltd. He will be concerned with the railway materials produced by all branches of the firm, and especially with those produced by the Workington Iron and Steel Company and Steel, Peech and Tozer. Mr. C. F. Ryan, A.M.I. Mech.E., has been appointed chief of development (railway materials) by the Steel, Peech and Tozer branch of the United Steel Companies, Ltd.

Launches and Trial Trips

BRITISH SEAFARER, motor tanker; built by R. and W. Hawthorn, Leslie and Co., Ltd., for the British Tanker Company, Ltd.; length overall 547ft, breadth moulded 69ft 6in, depth moulded 37ft 6in, deadweight 16,000 tons; Hawthorn-Doxford oil engine, six cylinders, 670mm diameter by 2320mm combined stroke, 6400 b.h.p. at 115 r.p.m. Launch, January 8th.

ATHELDUCHESS, motor tanker; built by R. and W Hawthorn, Leslie and Co., Ltd., for the Athel Line, Ltd.; length overall 494ft, breadth moulded 63ft 3½in, depth moulded 34ft 7in, deadweight 12,500 tons; twenty oil compartments and six summer tanks; Hawthorn-Doxford oil engine, four cylinders, 670mm diameter by 2320mm combined stroke, 4450 b.h.p. at 112 r.p.m.; two auxiliary boilers. Trial, January 10th.

DALFONN, motor tanker; built by Harland and Wolff, Ltd., for Sigval Bergesen, Stavanger; length between perpendiculars 580ft, breadth moulded 78ft, depth moulded 42ft 6in, deadweight 24,000 tons; Harland-Burmeister and Wain single-acting, two-cycle, opposed-piston oil engine, seven cylinders, 750mm diameter by 2000mm combined stroke. Launch, January 12th.

BOLETTE, motor tanker; built by Harland and Wolff, Ltd., for Fred Olsen and Co., Oslo; length between perpendiculars 580ft, breadth moulded 78ft, depth moulded 42ft 6in, deadweight 24,000 tons; twenty-seven oil compartments; Harland-Burmeister and Wain single-acting, two-cycle oil engine, seven cylinders, 750mm diameter by 2000mm combined stroke; two single-ended multitubular boilers. Trial, January 17th.

British Patent Specifications

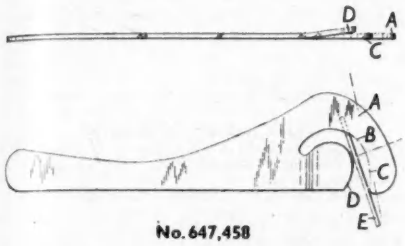
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

TOOLS AND WORKSHOP APPLIANCES

647,458. December 21, 1948.—IMPROVEMENTS IN OR RELATING TO TOOLS FOR CUTTING SLATES, ASBESTOS CEMENT SHEET MATERIAL AND LIKE COMPARATIVELY FRIABLE SHEET MATERIAL, The Tubela Engineering Company, Ltd., of 6, Furze Street, Bow, London, E.3, and Frank William Bourne, of 12, Sherringham Avenue, Tottenham, London, N.17.

In the construction illustrated the tool is formed from a single piece of metal plate between 0·10in and 0·15in thick. The head of the tool *A* is formed with a curved slot *B*, which for the greater part



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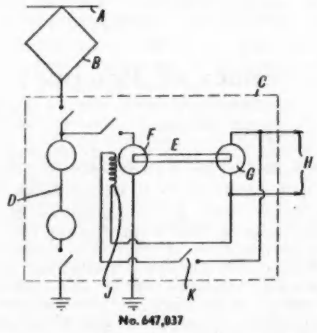
of its length is of substantially constant width but increases in width somewhat towards its open end. The concave edge *C* of the slot has sharp edges, while the convex edge portion *D* is bent out of the plane of the head *A*. The head portion is slightly tapering in cross-section. In operation the tool is applied to the edge of a piece of sheet material *E* as indicated, and the handle is then rocked in an anti-clockwise direction so that the cutting edge cuts a slot in the edge. Cutting is effected by breaking away the material over a width approximately equal to that of the edge *C*.—*December* 13, 1950.

ELECTRICAL ENGINEERING

647,037. September 15, 1948.—IMPROVEMENTS IN OR RELATING TO ELECTRICALLY DRIVEN LOCOMOTIVES, The General Electric Company, Ltd., of Magnet House, Kingsway, London, W.C.2; and James Charles Turrall, of The General Electric Company, Ltd., Engineering Works, Witton, Birmingham.

Referring to the drawing, the locomotive is arranged to obtain electric power at high voltage from an overhead line *A* by way of a pantograph *B*, which is arranged to be raised to engage the line and is kept in engagement by supplying compressed air to a piston and cylinder arrangement. The loco-



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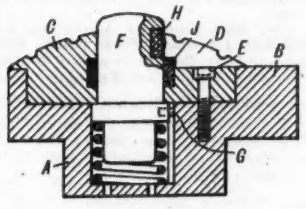
motive is provided with a chamber or enclosure *C*, which contains the main electrical circuits *D* of the locomotive and a motor generator set *E*, the motor *F* of which is arranged to be supplied from the line *A* and the generator *G* is arranged to provide power to lines *H* at a voltage considerably lower than that of the line *A*. The generator supplies current to a field winding *J* of the motor and entry to the chamber or enclosure *C* is prevented unless the main electrical circuits *D* of the locomotive are disconnected from the line *A*. In order to ensure that when the motor is disconnected from the line it cannot generate a dangerous high voltage if still running at speed, switching means *K* are provided in the circuit of the field winding *J*, which are arranged to open-circuit the field winding when the pantograph *B* is down; that is, when the compressed air supply to the pantograph cylinder is cut off. The switching device, which preferably takes the form of a contactor controlled by a pneumatic relay, is described and illustrated in the specification.—*December* 6, 1950.

ROAD TRANSPORT

648,542. January 15, 1949.—AN IMPROVED ROAD STUD OR TRAFFIC INDICATOR, Arthur Guise, of 25, Meriden Avenue, Wollaston, Stourbridge, Worcestershire.

This road stud, as shown in the drawing, consists of a cup-shaped housing *A*, in the rectangular upper part *B* of which is a convex cap *C* secured by screws *E* set in the radial slots *D*. A flanged plunger *F*



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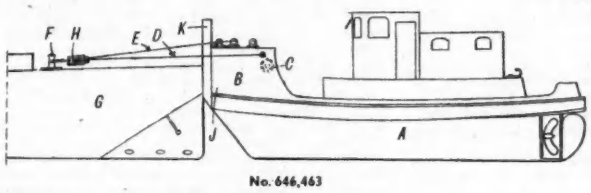
through the cap is held upwards by a helical spring, and a key *G* prevents rotation of the plunger in the cap. Reflectors *H* registering in the radial slots of the cap and a rubber ring *J* form a seal for the plunger. When a vehicle passes over the device the plunger is depressed and the reflectors are cleaned by the rubber sealing ring. If desired, non-skid grooves can be formed in the top of the plunger. *January* 10, 1951.

WATER TRANSPORT

646,463. January 9, 1948.—IMPROVED WATER-BORNE VESSEL DESIGNED FOR THE PROPULSION OF BARGES AND THE LIKE, Edward George Jones, of Brentside Wharf, Brentford, Dock Road, Brentford, Middlesex.

Referring to the drawing, the propulsion unit *A* is a vessel having a comparatively small moulded depth and a short freeboard. Its raised bow or stem superstructure *B* accommodates port and starboard winches *C* by means of which a pair of cables *D* and *E* may be attached to bollards *F* mounted on and forming a usual part of the barge



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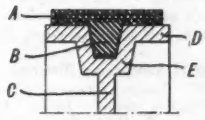
construction. To avoid chafing of the cables *G* it is preferred to pass them round pulleys or sheaves *H* connected with chain loops, which can be dropped over the bollards. Although the deck of the propulsion unit is low in comparison with an unladen barge, it is sufficient for an occupant of the wheelhouse to have clear vision over the raised bow of the unit and the top of the barge. The bow of the propulsion vessel is formed with a round nose *J* and has a vertical bolster *K* on each side of the centre line. Contact is made between the two vessels when the connecting cables *D* and *E* have been drawn taut. The bolsters *K* counteract any tendency of the unit to slip laterally with respect to the barge, whilst it is being propelled. It has been found that with a moulded depth of about 6ft, an overall length of about 30ft and other dimensions proportionate, a suitable waterborne unit can take an engine of about 100 h.p. and be small enough overall to avoid unwieldiness when two vessels are attached together.—*November* 22, 1950.

MISCELLANEOUS

648,560. September 18, 1948.—IMPROVEMENTS IN BELT DRIVING DEVICES, Nils Olof Bergquist, of Grävlingsvägen 64, Appelviken, near Stockholm, Sweden.

The invention has for its object to create a belt drive in which both the disadvantages of flat belts and wedge belts are eliminated. Thus, the belt drive according to the invention should be as free from slipping as are the wedge belt drives, and at the same time it should be of such construction that the belt will run off from the pulleys as easily as does a flat belt. The drawing shows a cross-section through the belt and adjacent portion of a pulley over which the belt is running. The belt consists of a flat main portion *A* for transmitting the essential part of the driving power, and an inwardly projecting ridge *B* integral with the main portion and extending in the longitudinal direction of the belt. Thus, the cross-section of the belt is substantially in the shape of a depressed T. Preferably, the belt is made of vulcanised rubber or another elastic material, and reinforcing layers of cords or canvas may be embedded in the main portion *A*. The pulley *C* has a substantially cylindrical portion *D* for co-operation with the main portion *A* of the belt, and a circumferential groove *E*



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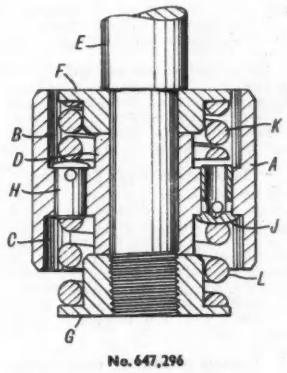
which corresponds to the ridge *B* of the belt. Preferably the shape of the groove is made in accordance with the diameter of the pulleys. Thus, the lateral extension of the bottom of the groove should be larger, the smaller the pulley is, because a more abrupt bending of the belt will cause a greater expansion of the ridge. Belts having three longitudinal ridges and six ridges are shown in the specification. An essential feature of the invention is that the flat main portion of the belt transmits the essential part of the power, and the ridge or ridges give a firm grip of the belt in the pulley.—*January* 10, 1951.

647,296. May 5, 1948.—IMPROVEMENTS IN OR RELATING TO PISTONS FOR HYDRAULIC SHOCK ABSORBERS, Noel Banner Newton, of Newton and Bennett Works, Valetta Road, Acton, London, W.3.

A piston for a hydraulic shock absorber of the kind referred to is characterised in that it is formed with an annular groove in each end face, leaving a medial web in which are formed straight and axially parallel valve passages in which the piston or valves are located and guided. Some of the valves are seated against one side and the others seated against the other side of the web, with a single coil spring in each groove engaging the valve heads. In the example of the invention shown in the drawing a piston *A* for a hydraulic shock absorber is 3in in diameter and 2⅜in in length. In each end face there is formed an annular groove *B* and *C* respectively, 1in and ¼in in depth, to leave a central hub *D* of 1⅛in diameter and a piston wall 3/16in thick. Thus, the piston has a central web of ⅛in thickness, in which are formed six through passages of 1/16in diameter. The piston head is fixed on the end of the piston rod *E* with an abutment collar *F* between a shoulder on the piston rod and the hub *D*, secured by a screwed collar *G* on the end of the piston rod. In the passages in the web of the piston are headed piston valves *H* and *J*, all of which are of the same size, but with the three valves *H* spaced at 120 deg. arranged to open on the closing stroke (i.e., with their heads above the piston) and the other three intermediate ones *J* arranged with their heads on the under or nut side of the piston. A spring *K* engages the heads of the valves *H*, while a somewhat



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heavier spring *L* engages the heads of the valves *J*. The heads of the valves are domed so that, should the valves lift unequally, causing the spring to cant, the spring can roll and not cause tilting or otherwise affect the action of the valves, the spring pressure remaining substantially at the centre of the valve head. Each valve has a hollow cylindrical stem, by which it is guided in its passage, there being radial holes through the wall of each stem immediately under the head. In operation, on the closing stroke, the three valves *H* can be raised against the closing pressure of the spring *K*.—*December* 13, 1950.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Mon., Feb. 5th.—LEEDS BRANCH: Great Northern Hotel, Wellington Street, Leeds, 1, "Fractional H.P. Motors," J. W. Bottomley, 7.30 p.m.——SHEFFIELD BRANCH: Royal Victoria Hotel, Sheffield, "Electric Lamp Manufacture," 7.30 p.m.

Tues., Feb. 6th.—W. LONDON BRANCH: Town Hall, Hammersmith, "Lighting Planning—Accuracy or Approximation," C. J. Misslebrook, 7.30 p.m.

Wed., Feb. 7th.—N. LONDON BRANCH: "Three Jolly Butchers" Hotel, Wood Green, N.22, "Mechanical Refrigeration and its Application," W. Boag, 8.15 p.m.——YORK BRANCH: Royal Station Hotel, York, "High Frequency Heating," H. E. Anderson, 8 p.m.

Fri., Feb. 9th.—NOTTINGHAM BRANCH: Demonstration Theatre, Electricity Showrooms, Smithy Row, Nottingham. "The Application of High Frequency Heating," S. W. Burfitt, 7.30 p.m.——S.E. LONDON BRANCH, S.E. London Technical College, Lewisham Way, S.E., "Resistance Welding," E. C. Slade, 8.15 p.m.

Birmingham Association of Mechanical Engineers

To-day, Feb. 2nd.—James Watt Memorial Institute, Great Charles Street, Birmingham, "The Development of Industrial Weighing," L. Sanders, 7 p.m.

British Institute of Management

Tues., Feb. 6th.—Management House, 8, Hill Street, London, W.1, "Methods—Time—Measurement," H. B. Maynard, 5.30 p.m.

British Institution of Radio Engineers

Wed., Feb. 7th.—MERSEYSIDE SECTION: Electricity Service Centre, Whitechapel, Liverpool, "A Transmitter for an Experimental Eight-Channel. Carrier Wire-Broadcasting System," R. G. Kitchenn, 7 p.m.

Engineer Buyers' and Representatives Association

To-day, Feb. 2nd.—Imperial Hotel, Temple Street, Birmingham, "Impressions on American Productivity," A. Nicholl, 7.30 p.m.

Engineers' Guild

Thurs., Feb. 8th.—Caxton Hall, Westminster, S.W.1, "The Engineer in Industry," A. L. L. Baker, 6 p.m.

Illuminating Engineering Society

To-day, Feb. 2nd.—BATH AND BRISTOL CENTRE: Grand Hotel, Bristol, "Shop Window Lighting," T. S. Jones, 7 p.m.

Mon., Feb. 5th.—LEEDS CENTRE: 24, Aire Street, Leeds, 1, "Analysis of Lighting Problems in an Industrial Undertaking," F. G. Copland, 7 p.m.——SHEFFIELD CENTRE: The University, Weston Bank, Sheffield, 10, Presidential Address, L. J. Davies, 6 p.m.

Tues., Feb. 6th.—STOKE-ON-TRENT GROUP: 31, Kingsway, Stoke-on-Trent, "Stage Lighting," E. Faraday, 6 p.m.

Wed., Feb. 7th.—EDINBURGH CENTRE: Lighting and Cleansing Department, High Street, Edinburgh, "Effect of Artificial Lighting on Occupational Health," H. H. Bell, 7 p.m.——NEWCASTLE CENTRE: Minor Durrant Hall, Oxford Street, Newcastle-upon-Tyne, "Street Lighting," A. J. Ogle, 6.15 p.m.

Thurs., Feb. 8th.—GLASGOW CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Effect of Artificial Lighting on Occupational Health," H. H. Bell, 6 p.m.——MANCHESTER CENTRE: Reynolds Hall, College of Technology, Sackville Street, Manchester, 1, "The Scientific Relationship Between Illumination and Photography," L. H. A. Carr, 6 p.m.

Fri., Feb. 9th.—BIRMINGHAM CENTRE: Imperial Hotel, Temple Street, Birmingham, "Lighting for the Prevention of Industrial Accidents," E. W. Murray, 6 p.m.——LEICESTER CENTRE: E. Midlands Electricity Board, Charles Street, Leicester, "Floodlighting," R. O. Ackerley, 6.30 p.m.

Incorporated Plant Engineers

Mon., Feb. 5th.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, W.C.2, "Capital Outlay," Bertram White, 7 p.m.

Tues., Feb. 6th.—S. WALES BRANCH: Grand Hotel, Westgate Street, Cardiff, "Survey and Report (Civil Engineering Plant)," R. M. Pringle, 7.30 p.m.

Thurs., Feb. 8th.—NEWCASTLE-ON-TYNE BRANCH: Royal Turks Head Hotel, Grey Street, Newcastle-upon-Tyne, "Steam, CO_2 and Draught," Film Show and Discussion, 7.30 p.m.

Institute of British Foundrymen

Mon., Feb. 5th.—SHEFFIELD BRANCH: Royal Victoria Station Hotel, Sheffield, "Oxygen as an Aid to Production of Carbon Foundry Steel in the Arc Furnace," A. C. Brearley, 7.30 p.m.

Wed., Feb. 7th.—LANCASHIRE BRANCH: Engineers' Club, Albert Square, Manchester, "Some Aspects of Non-Ferrous Founding," T. Freeman, 7 p.m.

Thurs., Feb. 8th.—LINCOLNSHIRE BRANCH: Technical College, Lincoln, "Patternmaking," S. A. Horton, 7.15 p.m.

Institute of Industrial Supervisors

Wed., Feb. 7th.—WEST BROMWICH SECTION: Grammar School, West Bromwich, "The Foreman and Human Relations," W. H. Temple, 7.45 p.m.

Institute of Road Transport Engineers

Mon., Feb. 5th.—SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Trends in Vehicle Design," P. M. A. Thomas, 7.30 p.m.

Institution of Chemical Engineers

Tues., Feb. 6th.—Geological Society, Burlington House, Piccadilly, W.1, "Applicability of Vapour-Liquid Equilibria to Extractive Distillation," F. H. Garner and S. R. M. Ellis, 5.30 p.m.

Institution of Civil Engineers

Tues., Feb. 6th.—Great George Street, Westminster, S.W.1, "The Design and Construction of Some Slipways up to 1200 Tons," G. C. Grove and D. H. Little, 5.30 p.m.

Thurs., Feb. 8th.—MIDLANDS ASSOCIATION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Arley Tunnel—Remedial Works Following Subsidence," C. W. King, 6 p.m.

Institution of Electrical Engineers

Mon., Feb. 5th.—S. MIDLANDS CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Planning of an Electricity Board System," G. O. McLean, 6 p.m.

Tues., Feb. 6th.—N. MIDLAND STUDENTS' SECTION: E.L.M.A. Lighting Service Bureau, 24, Aire Street, Leeds, "Textile Electrification," A. J. Francis, 7 p.m.

Wed., Feb. 7th.—RADIO SECTION: Savoy Place, Victoria Embankment, W.C.2, "Radio-Valve Life Testing," R. Brewer, 5.30 p.m.

Fri., Feb. 9th.—EDUCATION DISCUSSION CIRCLE: Savoy Place, Victoria Embankment, W.C.2, Discussion on "Teaching Mechanics to Engineers," 6 p.m.

Institution of Engineering Inspection

Tues., Feb. 6th.—S.W. BRANCH: Grand Hotel, Bristol, Films and Technical Commentary, 7.30 p.m.

Wed., Feb. 7th.—BIRMINGHAM BRANCH: Chamber of Commerce, Birmingham, "Electronics in Industry with a Bearing on Inspections," S. R. Judd, 7.30 p.m.

Institution of Heating and Ventilating Engineers

Wed., Feb. 7th.—E. MIDLANDS BRANCH: School of Technology, The Newarke, Leicester, "Vacuum Steam Heating," C. F. Assheton, 6.30 p.m.

Institution of Mechanical Engineers

To-day, Feb. 2nd.—Storey's Gate, St. James's Park, S.W.1, "Industrial Design and its Relation to Machine Design," H. G. Conway, 5.30 p.m.——N.E. BRANCH, GRADUATES' SECTION: Head, Wrightson and Co., Ltd., Eaglescliffe Foundry, Eaglescliffe, near Stockton-on-Tees, "The Overhaul and Repair of Road Vehicles," A. H. Moore, 7 p.m.

Mon., Feb. 5th.—N.E. BRANCH: Neville Hall, Westgate Road, Newcastle-upon-Tyne, "Thirty Years' Development of Opposed-Piston Propelling Machinery," W. H. Purdie, 6 p.m.

Tues., Feb. 6th.—COVENTRY A.D. CENTRE: Craven Arms Hotel, High Street, Coventry, "Some Thoughts on the Steering and Stability of Single-Track Vehicles," R. A. Wilson-Jones, 7 p.m.

Wed., Feb. 7th.—SCOTTISH BRANCH: Technical College, Dundee, "Thirty Years' Development of Opposed-Piston Propelling Machinery," W. H. Purdie, 7.30 p.m.

Thurs., Feb. 8th.—SCOTTISH BRANCH: Royal Technical College, Glasgow, "Thirty Years' Development of Opposed-Piston Propelling Machinery," W. H. Purdie, 7.30 p.m.

Fri., Feb. 9th.—Storey's Gate, St. James's Park, S.W.1, "New Formulæ for Water Flow in Pipes," J. S. Blair; "Friction Losses in Turbulent Pipe-Flow," L. E. Prosser, R. C. Worster and S. T. Bonnington.——5.30 p.m.—SCOTTISH BRANCH: Robert Gordon's College, Aberdeen, "Thirty Years' Development of Opposed-Piston Propelling Machinery," W. H. Purdie, 7.30 p.m.

Institution of Post Office Electrical Engineers

Tues., Feb. 6th.—Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2, "Some Aspects of Electronic Circuit Design," S. W. Broadhurst and A. W. M. Coombes, 5 p.m.

Institution of Production Engineers

Tues., Feb. 6th.—READING SUB-SECTION: Great Western Hotel, Reading, "Magnesium Foundry Practice," G. B. Partridge, 7.15 p.m.

Wed., Feb. 7th.—LONDON GRADUATE SECTION: 36, Portman Square, London, W.1, "Cost Control in Engineering Production," L. W. Robson, 7.15 p.m.——LIVERPOOL GRADUATE SECTION: Exchange Hotel, Tithebarn Street, Liverpool, "Analysis of the Phrase 'Near Enough' (Permissible Tolerance) as Applied to Measuring Processes," E. Walshaw, 7.45 p.m.——NOTTINGHAM SECTION: Victoria Station Hotel, Milton Street, Nottingham, "Artistic Metal Box Manufacture," G. Gledhill, 7 p.m.——S. ESSEX SUB-SECTION: Mid-Essex Technical College, Chelmsford, "Material Handling," W. J. T. Dimmock, 7.30 p.m.——WOLVERHAMPTON SECTION: County Technical College, Wednesbury, "Mechanical Handling Techniques," J. Bain, 7 p.m.

Thurs., Feb. 8th.—SOUTHERN SECTION: Polygon Hotel, Southampton, "Industrial Applications of the Lost Wax Process," A. Short, 7 p.m.

Fri., Feb. 9th.—W. WALES SUB-SECTION: Central Library, Alexandra Road, Swansea, "Materials Handling—Some Impressions of my visit to America," W. J. T. Dimmock, 7.30 p.m.

Institution of Sanitary Engineers

Tues., Feb. 6th.—Caxton Hall, Westminster, S.W.1, "The Sanitary Engineer and Reports on Chemical Analyses," C. J. Regan, 6 p.m.

Institution of Structural Engineers

To-day, Feb. 2nd.—WESTERN COUNTIES BRANCH: College of Technology, Bristol, "A Chapter of Engineering a Century Ago," Andrew Robertson, 6.15 p.m.

Tues., Feb. 6th.—NORTHERN COUNTIES BRANCH: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Concrete Control for Small Works," N. J. Ruffle, 6.30 p.m.——NORTHERN IRELAND BRANCH: College of Technology, Belfast, Discussion on British Standard Specification No. 449, 7.15 p.m.——WALES AND MONMOUTHSHIRE BRANCH: S. Wales Institute of Engineers, Park Place, Cardiff, "Modern Trends in Structural Design," W. S. Atkins, 6.30 p.m.

Thurs., Feb. 8th.—11, Upper Belgrave Street, London, S.W.1, "The Construction of an Extension to a Factory at Silvertown," F. G. Etches, 6 p.m.

Institution of Works Managers

To-day, Feb. 2nd.—NOTTS AND DERBY BRANCH: Mechanics' Institute, Nottingham, "Why Nationalised Industry Cannot Be Efficient," L. C. Ord, 7.30 p.m.

Tues., Feb. 6th.—LEICESTER BRANCH: College of Technology, Leicester, "Designing for Standardisation and Production," J. E. Chadbund, 7 p.m.——MERSEYSIDE BRANCH: Adelphi Hotel, Liverpool, "Personnel Problems of a Works Manager," A. Scholes, 6.30 p.m.

Thurs., Feb. 8th.—WEMBLEY SUB-BRANCH: The Plough, Kenton, "The Study of the Mind," I. H. Child, 12.30 p.m.——TEES-SIDE BRANCH: Vane Arms Hotel, Stockton, "Some Aspects of Operator Training," E. F. L. Brech, 7.30 p.m.

Fri., Feb. 9th.—MANCHESTER BRANCH: Grand Hotel, Manchester, "Industrial Law," L. Walsh, 6.30 p.m.

Junior Institution of Engineers

To-day, Feb. 2nd.—39, Victoria Street, London, S.W.1, Film Evening, "Wonder Rock," introduced by H. Wallace, 6.30 p.m.

Mon., Feb. 5th.—N.W. SECTION: Geographical Society, 16, St. Mary's Parsonage, Manchester, "Ramble Through Patent Fields," A. C. Ashton, 7 p.m.

Wed., Feb. 7th.—MIDLAND SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "From Stoveplate to Mechanised Moulding," H. A. Wainwright, 7 p.m.

Fri., Feb. 9th.—39, Victoria Street, Westminster, S.W.1, "The Hydrodynamics of Ship Design," H. Volpich, 6.30 p.m.

Manchester Association of Engineers

To-day, Feb. 2nd.—Engineers' Club, Albert Square, Manchester, "Planning for Production Efficiency," Sir Claude D. Gibb, 6.45 p.m.

Manchester Geological and Mining Society

Thurs., Feb. 8th.—Mining and Technical College, Wigan, "Strata Movement in Pit Bottoms," W. J. Bourne, 3.15 p.m.

North East Coast Institution of Engineers and Shipbuilders

Fri., Feb. 9th.—Mining Institute, Neville Hall, Newcastle-upon-Tyne. "The Electrification of Shipyards," J. S. McCulloch, 6.15 p.m.

Royal Society of Arts

Mon., Feb. 5th.—John Adam Street, Adelphi, London, W.C.2, "Training for Industry and the Professions," Sir Godfrey Ince, 6 p.m.

Society of Engineers

Mon., Feb. 5th.—Geological Society, Burlington House, Piccadilly, W.1, Presidential Address, P. Sison Ham, 5.30 p.m.

Women's Engineering Society

Tues., Feb. 6th.—LONDON BRANCH: E.L.M.A. Lighting Bureau, 2, Savoy Hill, W.C.2, "Festival Lighting," 7 p.m.——MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, "The Gas Turbine—A New Prime Mover," T. MacInerney, 6.30 p.m.

Codes of Practice

The Codes of Practice Committee for Civil Engineering, Public Works and Building and Constructional Work is under the ægis of the Ministry of Works. Codes are issued on behalf of the Committee by the British Standards Institution, 24–28, Victoria Street, London, S.W.1.

DURABILITY OF BUILDINGS

The Council for Codes of Practice for Buildings has now issued in final form **Chapter IX**, "Durability," of the Code of Functional Requirements of Buildings. The chapter contains brief notes on the designed life, satisfactory life and maintenance requirements of buildings or parts of buildings. Six appendices giving useful general information are included. In these appendices the particular causes of deterioration of buildings and installations are analysed, and appropriate protective and preservative treatments are recommended. Information is given on the susceptibility of building materials to deterioration, in particular of metals, timber, cement products, stones, clay bricks and tiles, bituminous materials and paints. Other matters dealt with in the appendices are the effect of design upon the durability of materials, the classification of water supplies in relation to their effect upon metals, of ground water and soil in relation to their effect upon concrete, and of atmospheric pollution conditions. The chapter includes tables giving approximate rates of corrosion of steel and of zinc coatings on steel, recommended protective measures for metals, and a classification of sulphate soil conditions affecting concrete, with recommended precautionary measures.